

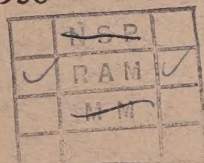
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INDIAN TEA ASSOCIATION

SCIENTIFIC DEPARTMENT

TOCKLAI EXPERIMENTAL STATION

ANNUAL REPORT—1956



INDIAN TEA ASSOCIATION

SCIENTIFIC DEPARTMENT



TOCKLAI EXPERIMENTAL STATION



ANNUAL REPORT—1956

CONTENTS

	PAGE
DIRECTOR'S REPORT	1
Staff	1
Visitors	3
Touring	4
Meetings	4
Conference	5
Courses	6
Publications	7
Labour Relations	8
Library	8
Guest House	9
Medical	9
Building and Maintenance	10
Research and Experiment	11
Advisory Services	13
Butler's Wharf Laboratory	15
PHYSICO-CHEMICAL BRANCH	16
Staff	16
Research and Experiment	16
Publications	27
Advisory	27
BOTANICAL BRANCH	32
Staff	32
Research and Experiment	32
Tea Breeding	32
Morphology and Taxonomy	32
Illumination and Nutrients	34
Publications	52
Advisory	52
AGRICULTURAL BRANCH	53
Staff	53
Research and Experiment	53
Advisory	84
Borbhetta Station Report	85

CONTENTS (*Contd.*)

	PAGE
PLANT PATHOLOGY BRANCH—ENTOMOLOGICAL SECTION.	87
Staff	87
Research and Experiment	87
Scientific Publications	105
Advisory	105
General Remarks	106
PLANT PATHOLOGY BRANCH—MYCOLOGICAL SECTION.	107
Staff	107
Research and Experiment	107
Scientific Publications	117
Advisory	117
General Remarks	118
Bacteriology	123
BIOCHEMICAL BRANCH.	124
Staff	124
Research and Experiment	124
Fundamental Research	124
Manufacturing Experiments ..	130
Publications	131
Advisory	132
BIOCHEMICAL BRANCH—TEA TASTING SECTION. ...	133
Staff	133
Tasting	133
Advisory	133
ENGINEERING DEVELOPMENT BRANCH.	134
Staff	134
Research and Experiment	134
Publications	138
Advisory	139
General	139

CONTENTS (*Contd.*)

	PAGE
ASSAM ADVISORY BRANCH—ASSAM VALLEY ...	140
Staff	140
Touring	140
Meetings	141
Lectures and Demonstrations	141
Courses	142
Advisory Correspondence	142
Publications	142
Technical Reports	143
Experiments	145
ASSAM ADVISORY BRANCH—CACHAR	149
Staff	149
Touring	149
Meetings	149
Lectures and Demonstrations	149
Courses	150
Publications	150
Experiments	150
Branch Experimental Area	150
Garden Experiments	152
Silcoorie Station Report	156
WEST BENGAL ADVISORY BRANCH	158
Staff	158
Touring	158
Meetings	158
Courses	158
Advisory Correspondence	158
Experiments	158
Dooars Experiments	159
Darjeeling Experiments	160
INDIAN TEA ASSOCIATION (LONDON) : CHEMICAL LOBORATORY, BUTLER'S WHARF	162
Introduction	162
Research	162
Appendix—Chemical Constituents of tea	165

ANNUAL REPORT FOR 1956

DIRECTOR'S REPORT

H. FERGUSON—Director

A. D. SWAN—Scientific Officer (H.Q.)

STAFF

During the year the following appointments were made:—Mr. W. J. Grice and Mr. D. J. Gray, who joined the station after a period of training in U.K., took up their appointments as Advisory Officers in Calcutta on 18th September, and arrived at Tocklai on 20th September. Mr. H. Mitra joined the staff as Additional Advisory Officer on 2nd January, and Mr. B. M. Barua was appointed Temporary Maintenance Engineer on 1st September. Mr. D. N. Borbora was appointed Temporary Assistant Research Engineer on 10th September.

A new post of Accountant was created during the year and Mr. M. K. Choudhury was appointed to this post.

Consequent upon a re-organisation of the West Bengal Advisory Branch, Mr. A. D. Swan was transferred from Darjeeling to Tocklai as Scientific Officer, Headquarters.

The following officers were on overseas leave and/or duty during 1956:—Mr. R. I. Macalpine, Dr. N. B. Chanda, Mr. J. M. Trinick, Mr. E. D. Heath, Mr. N. G. Gokhale, and Mr. I. McTear. Mr. Wood had short leave in the U.K. from 20th April to 15th May. Mr. D. N. Borbora, Mr. S. Basu and Mr. J. H. Blair were on normal leave during the year. Dr. P. C. Sharma acted for the Advisory Officer, Cachar, from 3rd June—22nd December.

During 1956 the following Officers had local leave:—Mr. H. Ferguson, Dr. Das, Mr. Glover, Mr. Dutta, Dr. Wight, Dr. Barua and Mr. Green.

The Senior Staff at 31st December, 1956 is listed below under Branches:—

Directorate:

Director	...	...	H. Ferguson, B.Sc. (Hons.),
Scientific Officer (H.Q.)	...	...	A. D. Swan, B.Sc. (St.A.),
Personal Assistant to the			
Director	...	...	J. H. Blair.
Maintenance Engineer	...	...	B. M. Barua (Temporary).

Physico-Chemical Branch:

Senior Physical Chemist	...	N. G. Gokhale, B.Sc. (Bom. & Lond.).
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Botanical Branch:

Senior Botanist and Plant			
Physiologist	...	...	W. Wight, Ph.D. (Leeds),
Botanist	...	...	M. J. Green, B.Sc. (Edin.),
Plant Physiologist	...	...	D. N. Barua, Ph.D. (Cantab.).

Agricultural Branch :

Senior Agriculturist	...	S. K. Dutta, B.Sc. (Bom. & Wales.),
Assistant Agriculturist	...	S. K. Basu, B.Sc. Ag. (Delhi), Assoc. I.A.R.I.

Plant Pathology Branch:

Senior Entomologist	...	G. M. Das, M.Sc. (Cal.) D.I.C., Ph. D. (Lond.).
Mycologist	...	K. C. Sarmah.

Biochemical Branch:

Senior Biochemist	...	D. J. Wood, B.A. (Cantab.).
Biochemist	...	N. B. Chanda, M.Sc. (Dac.), Ph. D. (Edin.)
Tea Taster	...	J. M. Trinick.

Engineering Development Branch :

Senior Research Engineer	I. McTear.
Assistant Research Engineer	D. N. Borbora, B.Sc. (Mining (Benaras), M.Sc. (Engineering) (Lond.) D.I.C.

Assam Valley Advisory Branch :

Senior Advisory Officer,	
Assam	P. M. Glover, M.B.E., B.Sc.,
Advisory Officer, Cachar ...	E. D. Heath, B.Sc. Dip. Ag. (Cantab.),
Advisory Officer, North Bank (Designate) ...	D. J. Gray, B.A. (Cantab.)
Assistant Advisory Officer	P. C. Sharma, Ph.D. M.Sc., F.L.S. (London).

West Bengal Advisory Branch :

Senior Advisory Officer ...	R. I. Macalpine, B.Sc. (Forestry).
Advisory Officer (Designate) ...	W. J. Grice, B.A. Dip. Ag. (Cantab.).
Assistant Advisory Officer	H. Mitra, B.Sc.

VISITORS

The following members of the Indian Tea Association visited the Station:—

Mr. Vernede, Deputy Chairman of the Indian Tea Association, London ; Mr. A. N. Stuart Chairman of the London Advisory Committee ; Mr. Kilburn and Mr. Colvin also of the London Advisory Committee ; Lt. Col F. W. S. Roberts and Mr. D. C. Hodson of the Indian Tea Association, London ; Mr. D. L. Betts, Mr. Walsh and Mr. Yashanoff, of the Indian Tea Association, Calcutta.

Members of the Indian Tea Association, Calcutta who attended the Conference are mentioned below under that head.

A number of other visitors associated with the tea industry in London and Calcutta visited the station, and many local Planters, Superintendents and Visiting Agents called to discuss their problems and seek advice.

Distinguished visitors not associated with the Indian Tea Association are listed below in the chronological order of their visits :—

General Shrinagesh, Chief of Army Staff, India ; Shri Khandubhai Desai, Labour Minister, Government of India ; Mr. D. L. Downie, of the Mimosa Tea Research Station, Nyasaland ; Dr. F. H. Abbasi of the Pakistan Tea Board ; Mr. Peter de Jong of United Planters' Association of Southern India ; Dr. S. M. Sikha, Head of Botany Division of Indian Agricultural Research Institute ; Dr. D. C. Kaith, Director of Soil Conservation Board, India ; Mr. K. G. Bodensteiner, Agricultural Officer, American Consul General's Office, Calcutta ; Shri Bishnu Ram Medhi, Chief Minister of Assam ; Air Commodore Arjan Singh, D.F.C., A.O.C., Operational Command, I.A.F. ; Mr. I. A. Rufus of Marshall & Co. accompanied by Mr. J. Talbot and Mr. R. Corson from Mauritius ; H. E. The Governor of Assam, Dr. Saiyid Fazl Ali ; Mr. R. B. Vaghaiwalla, Deputy Commissioner, Sibsagar ; three representatives of the U.S.S.R. Tea Industry ; Mr. Vassiliades of the Ministry of Agriculture, Argentina ; Dr. Patel, Adviser to the Ministry of Agriculture, Government of India, New Delhi ; Dr. M. S. Randhawa, Vice President, Indian Council of Agricultural Research ; and Dr. Tag, Agricultural Adviser to Ruhr-Stickstoff.

TOURING

The Director visited gardens in Darjeeling, Terai, and Dooars between 11th and 21st January, and gardens in Cachar in February. Assam Valley Gardens were visited from time to time throughout the year.

MEETINGS

The Director attended, or was represented at, the following meetings during the year :—

The Terai Planters' Association Annual General Meeting on 13th January ; Dooars Branch Indian Tea

Association Annual General Meeting on 14th January; Surma Valley Branch Indian Tea Association Annual General Meeting on 8th February; The Darjeeling Branch Indian Tea Association Annual General Meeting on 4th February, (attended by Mr. S. K. Dutta representing the Director and Mr. A. D. Swan); The Indian Tea Association, Calcutta, Annual General Meeting on 9th March; Quarterly Meetings of the Scientific Department Sub-Committee on 8th March, 11th May, 28th July in Calcutta and 12th November at Tocklai; Tea Board *Ad-hoc* Committee Meetings on 10th March, 18th July, 30th July, 28th September and 18th December in Calcutta. Assam Tea Planters' Association Meeting on 21st March; The Eleventh Meeting of the Crops and Soils Wing of the Board of Agriculture and Animal Husbandry at Simla from 14th—23rd June; Annual General Meeting of the United Planters' Association of Southern India from 25th August to 1st September; An Extraordinary Annual General Meeting of the Assam Branch Indian Tea Association on 16th November, and the Annual General Meeting of the Assam Branch Indian Tea Association on 17th November at Dibrugarh.

In addition some locally held Assam Branch Indian Tea Association Zone and Circle meetings, and meetings of the Governing Bodies of the Assam Agricultural College and Prince of Wales College were attended.

CONFERENCE

The Thirteenth Annual Conference was held at Tocklai on the 13th, 14th and 15th November. The subject of the first day's session was "Spacing and Arrangement in Tea Planting," and papers on this subject were delivered by Dr. Wight, Mr. Dutta, Mr. Glover and Mr. McTear (read by Mr. Borbora). This was followed by a general discussion on this subject, and the discussion of delegates' questions relating to this and associated subjects. The subject of the second day's session was "Pruning of Mature Tea in Relation to Yield and Longevity of the Crop." Papers on this subject were delivered by Mr. Dutta, Dr. Barua, Mr. Sarmah and

Mr. Macalpine. These were again followed by discussion of the papers and delegates' questions. The third day was reserved for demonstration and discussion of Engineering Development and Manufacture. During the afternoon delegates visited Borbhetta, where the pruning/harvesting machine and spraying machinery were demonstrated, and experiments inspected; or toured the laboratories at Tocklai.

Full Conference Proceedings have been distributed to those who attended, and to Indian Tea Association committee members.

In addition to the Tocklai staff, the following attended the Conference :—

Mr. C. D. Wilson, Chairman, Scientific Sub-Committee, Mr. P. Nicholls, Mr. G. Kydd, Mr. R. L. Hards, Mr. N. S. Coldwell, Mr. E. H. Adams, members of the Scientific Department Sub-Committee, Mr. F. G. Johnson, Mr. R. C. Reynolds, Mr. Hyatt, Mr. J. D. Bruce, Mr. D. I. Simpson, Mr. J. F. Hall, Mr. T. J. Hardingham, Mr. R. Banerjee representing Indian Tea Association Branches and the Terai Planters' Association, Mr. Peter de Jong and Mr. Ananda Rao of the United Planters' Association of Southern India; Mr. R. G. Philipp, Mr. J. A. Morice, Dr. A. Gilroy, Mr. P. K. Barooah, Mr. B. H. N. McNeill, Mr. H. J. Walsh and Mr. I. H. Nish.

COURSES

Three general lecture courses of five days duration were held during March and were attended by 75 planters and 7 Borbhetta Trainees. The courses were mainly run by the advisory staff and covered all the main aspects of Tea Culture and Manufacture. The Agricultural branch ran a three week practical course in Vegetative Propagation during April-May attended by 9 Planters; a special demonstration of vegetative propagation was given in September; and two 3-days Vegetative Propagation courses were run between 25th October and 3rd November. Nine apprentices received training during the year.

PUBLICATIONS

During the year the following Tea Encyclopaedia Serials, Journals and Articles were published.

Tea Encyclopaedia Serials :

- 10/2 "Pruning of Young Tea" (Assam kinds).
- 22/1 "Care and Maintenance of Tea Seed Baries".
- 24/1 "The Practical Significance of Botanical Nomenclature."
- 46/1 "Shade".
- 70/1 "Control of Primary Root diseases of Tea."
- 80/1 "Weed Control".
- 110 "Compatibility of Insecticides, Acaricides and Fungicides, commonly used in Tea."
- 111 "Silviculture of Shade."
- 112 "Ants and Their Nests."
- 113 "Scale Insects and Mealy Bugs on Tea Bushes."

Journals :

- "Two and a Bud" (Tocklai Newsletter) Vol. III No. 1, 2, 3 & 4.

Annual Report of the Scientific Department for 1955.

Articles and Scientific Papers :

- "Nitrogenous Fertilisers for Tea", by N. G. Gokhale—
Journal of Indian Society of Soil Science.
- "The Manuring Problem in Tea", by N. G. Gokhale—
Transactions of the 6th International Soil Congress,
Paris, 1956, Commission IV.
- "Commercial Selection and Breeding of Tea in India",
by W. Wight—World Crops.
- "The Practical Basis of High Yielding Tea," by W.
Wight and K. N. Dutta—Tea Trade and Industry.

- “Calcium Oxalate Crystals as an index of nutrient Uptake in the Tea” by D. N. Barua—Current Science.
- “Wilson’s Camellia” by P. K. Barua—Camellian.
- “Psychidae (Lepidoptera) on Tea in North East India”, by G. M. Das—Ann. & Mag. of Natural History.
- “New Psychids (Lep. Psychidae) from Assam”, by G. M. Das—Ann. & Mag. of Natural History.
- “The Association of Red Ant, *Oecophylla smaragdina* Fabr. with the Tea Coccid, *Coccus hesperidum* L” by R. N. Ganguli—44th Proceedings Indian Science Congress.
- “Tylose Formation in Tea” by K. C. Sarmah—Indian Phytopathology.
- “The Leucoanthocyanins of Un-Processed Tea-Leaf”, by E. A. H. Roberts, R. A. Cartwright and D. J. Wood—Journal of the Science of Food and Agriculture.
- “The Flavonols of Tea,” by E. A. H. Roberts, R. A. Cartwright, and D. J. Wood—Journal of the Science of Food and Agriculture.

LABOUR RELATIONS

Early in the year the Borbhetta and Tocklai Labour agitated for the payment of bonus in accordance with the Delhi agreement. While negotiations were in progress the Borbhetta labour went on strike from 2nd—4th May, and the Tocklai labour walked out on two occasions. As a result of negotiations a special allowance based on attendance was awarded. During the year the three unions which represent the employees and labour at Tocklai and Borbhetta have submitted complaints fairly regularly and some points raised by the Tocklai Employees’ Union had to be taken to conciliation.

LIBRARY

The librarian Mr. J. N. Borthakur retired from his post at the end of the year after over 39 years service at Tocklai.

At the end of December the library contained 1078 books mostly on agricultural and other subjects related to tea, 50 photostat copies and 50 maps. The library subscribes regularly to 66 journals and periodicals; 11 from India, 28 from the United Kingdom, 23 from the United States and 4 from other overseas territories. In addition 71 journals are regularly received in exchange, and a number of reprints, pamphlets and so on are received as gifts.

The following accessions were made during the year :—

Books	...	...	92
Journals	...	...	789
Pamphlets	...	...	655

Small outstation libraries are maintained at Advisory Offices in the Dooars and Cachar, and are regularly supplied with a few journals.

GUEST HOUSE

Redecoration and refurnishing of the Guest House continued during the year. A total of 465 overnight and 450 casual guests used the Guest House during the year. Many of the overnight guests spent several nights at the Guest House.

MEDICAL

The Resident Medical Officer reports that 14,901 cases were treated during the year. The most common illnesses were gastro-intestinal disorders, some due to food poisoning; helminthic and amoebic infections; influenza and bronchitis; gastritis and enteritis. There were five cases of appendicitis and two hysterectomies were done. Other cases which occurred were :—One case each of pulmonary and spinal tuberculosis, one case of Kala-azar, sporadic cases of jaundice, asthma, pneumonia, rheumatism, anaemia, pemphigus, impetigo, ring worm, scabies, dermatitis, ophthalmia, ulcer, ozena, rhinitis, stomatitis, nephritis, sytitis, herpes zoster. Five patients required prophylactic anti-rabic treatment.

The anti malaria control work at Tocklai and Borbhetta continued throughout the year and was directed mainly against

the known breeding areas of *Anopheles minimus*. The population of other mosquito species was kept down by regular spraying of all possible breeding places in and near the station with residual insecticides and malariol. The results of control measures may be considered satisfactory as no cases of malaria occurred during the year. 149 suspect blood slides were examined but all proved negative.

It is however necessary to report that during the year the fly population increased enormously, and, although special measures were adopted to combat this, the better known insecticides had little effect.

BUILDING AND MAINTENANCE

Construction.— A staff canteen and a new bungalow and outhouses were constructed by contract during the year. Extension of the Entomological laboratory, and construction of a balance room in the Biochemical laboratory were completed. Several partition walls in various buildings of the station were built to accommodate offices etc. Five domestic hot water systems were installed. The roofs of the Botanical, Biochemical, and Tea Tasting laboratories, and of the factory, withering house and five bungalows were painted. Internal decoration of 6 bungalows was done. Pent roofs were constructed on the two open porches of bungalow No. 4. Bungalows 4 and 6 were rewired and the floor of bungalow 11, repaired. Asbestos ceilings were installed in bungalows 9, 10 and 12, the Physico-chemical laboratory and a portion of the general store. Water pipes were laid and tanks and stagings constructed for the water supply to the Borbhetta Bungalows. Water was connected to the staff canteen and new bungalow at Tocklai. Part of the western section of the station was fenced as was the Borbhetta bungalow area and gates erected where necessary. At the end of the year two new staff quarters were under construction by contractor and should be completed early in 1957.

Station Extension.— During the year a plot of land adjoining the western boundary of Tocklai was purchased (this includes the new bungalow site). An area about half a mile distant from Tocklai was rented and a bungalow thereon purchased, at the end of the year.

Maintenance.— Running repairs and maintenance to all buildings, roads and fencing was carried out as and when required.

Machinery and Equipment.— A second generator was installed in the Borbhetta power house to allow of a continuous supply of electricity to the Borbhetta bungalows. Repairs and overhauls were carried out to the rolling room machinery and an air conditioning plant installed in the Biochemical Laboratory.

Station Transport.— A new Studebaker pick-up was purchased. The station Land-Rover was requisitioned by the Government in May and has not yet been returned.

RESEARCH AND EXPERIMENT

Detailed reports from each branch and section at Tocklai form the main part of this Annual Report, but a brief summary of important features of the research work is given here.

Physico-Chemistry and Meteorology.— The study of the effects on soil of prolonged use of Sulphate of Ammonia have been continued, the effect on calcium status being given special consideration in 1956. Studies in the availability of different types of phosphatic fertilizers and on uptake of chlorine by the tea plant were also carried out. Methods of evaluating crumb structure and methods of inducing symptoms of mineral deficiency were studied as a preliminary to further investigations on these subjects.

Botany.— The Botanical Branch continued to carry out its research activities on Tea Breeding ; Morphology and Taxonomy of the Tea Plant, specially in relation to the classification of tea populations; and Physiology of Tea, with particular reference to illumination and nutrients. In view of the long term nature of much of this work, only a few individual projects are reported upon in detail. The effects of artificial shading on soil and climatic environment, and on a number of characteristics of four clones, representing teas of known or possible different kinds, have been established, and are given in the branch report. The interactions of light intensity (degree of shade) and nitrogen have also been studied and reported on.

Agriculture.— Some thirty field experiments and a number of observation plots are conducted by this branch. The full experiments deal mainly with problems of manuring, plucking, pruning and shade of tea, and are essentially long term. The observation plots are mainly of green manure crops and shade trees. It is not possible to report on all experiments in one season, and only those which have reached an interesting stage are dealt with in this report. These include a report on method and time of planting of tea in relation to a number of other factors ; N.P.K. manuring of young, and of mature, tea ; interaction of nitrogenous manuring and shade ; and medium pruning of tea. Generally the results confirm the all importance of nitrogen at all stages of growth, though phosphate and potash may be of value for young and medium pruned tea. The importance of correct timing of planting and careful treatment for the less hardy Assam teas has also been established. Mechanical harvesting of tea, and the manuring of bamboos are also reported on.

Plant Pathology—Entomology.— During 1956 most of the time of this section was taken up with trials of insecticides and acaricides against the common pests of tea, and insufficient time was available for study of the insects themselves. Work on the control of Red Spider was continued, and, amongst other pests, special attention was paid to Looper Caterpillar and Flushworm, which were abnormally severe in some areas. A special study was made of Coccids and their relationship with Ants, and information on shade tree and green crop pests continued to be collected during the year.

Plant Pathology—Mycology.— As in the Entomological Section, much of the time of this branch was devoted to fungicidal trials. These include prophylactic spraying trials for control of Black Rot and Red Rust. In addition to these, trials of Shell D.D. fumigant against eelworms were carried out. While a reduction in eelworm count in the soil was recorded the D.D. had little effect on the extent of damage caused. Studies on the Tea Flower Disease attributed to *Sclerotinia* were continued. Routine records of the incidence of tea diseases were kept, and the occurrence of fungi on shade trees and green crops was recorded.

Biochemistry.— The work of this branch falls into two categories—fundamental research on the chemistry of tea, and manufacturing experiments. The latter are conducted in co-operation with the Engineering Development Branch and the Tea Taster. In the laboratory, studies were continued on physical and chemical changes during withering and on the isolation of the volatile constituents of tea. A new major project on the “Chemical Basis of Quality” was started, and preliminary results already indicate and confirm certain correlations between “quality” and content of certain of the chemicals constituents of fresh and manufactured leaf. Manufacturing experiments were mainly concerned with the development of new machines, and with the selection of clones.

Tea Tasting.— Approximately 6000 samples were tasted during the season—less than usual on account of the tea taster’s absence on leave. Most tastings were done in connection with manufacturing experiments, field experiments, and clonal selection. The later was done mainly for commercial estates.

Engineering Development.—Improvement of the machines being developed continued during the year, and comparative tests between orthodox rolling and the two continuous rolling machines were carried out during the season. In both cases satisfactory taster’s reports were obtained. Experiments with mechanical harvesting and mechanical pruning were continued. In particular the pruning machine was further developed, and functioned very satisfactorily in field trials. A continuous withering machine was fabricated at the end of the season and was subjected to preliminary trials.

ADVISORY SERVICES

Though considerable expansion in the Advisory Services took place during 1956 this will not be effective till 1957. In fact in 1956 the advisory services had to be somewhat curtailed in the Dooars and Darjeeling due to reorganisation and leave.

New advisory officers and assistant advisory officers to cater for both member and non-member gardens were in training in 1956. When these officers are finally installed the

advisory services will cover the North East India tea areas roughly as follows :—

<i>Advisory Officer's Unit</i>		<i>Approximate Acreage (Under tea)</i>
Assam South Bank (A.B.I.T.A. Zone I & II ...	...	1,70,000
Assam North Bank (A.B.I.T.A. Zone III) ...	...	60,000
Cachar ...	...	40,000
Assam (including Cachar) non-members ...	...	1,10,000
Total, Assam (4 officers) ...	...	3,80,000
Dooars ...	...	1,00,000
Darjeeling and Terai (officer will also assist in Dooars) ...	...	30,000
West Bengal (all areas) non-members ...	...	60,000
Total, West Bengal (3 officers) ...	...	1,90,000

Scientific Officers from Tocklai paid a number of advisory visits to tea gardens in 1956. These were generally in connection with specialised problems, though on occasion routine advisory visiting in the Dooars was undertaken by Senior Agriculturist, Tocklai. Scientific Officers' visits worked out at one (single day visit) per 6.06 member gardens in Assam Valley, 1 per 2.65 gardens in West Bengal, and 1 per 2.35 gardens in Cachar.

Assam Advisory Branch - Assam (Brahmaputra) Valley.—In the Assam Valley 95 member gardens and 3 non-member gardens were visited during the year. Many of these were visited on more than one occasion. In addition 12 gardens in Cachar and 11 gardens comprising the Assam Frontier Co., Chotanagpur Division in the Ranchi District were visited. Much advisory work was also carried out by means of correspondence and lectures, and during planters' visits to Tocklai. While these methods of disseminating advice are common to all districts they are relatively much more important in Assam. Field experiments in typical gardens throughout the district were continued and a number of machinery demonstrations were attended.

Assam Advisory Branch—Cachar.— 32 member gardens and 6 non-member gardens (comprising in all 108 separate visits) were visited during the year. A number of field experiments were carried out in gardens in the Cachar district and observation plots were maintained at the branch headquarters at Silcoorie.

West Bengal Advisory Branch.—As a result of reorganisation the Dooars, and Darjeeling and Terai, Advisory Services were combined in 1956, and for part of the year these had to be run direct from Tocklai. 69 member gardens and 3 non-member gardens were visited. Of these 47 were in the Dooars, 23 in Darjeeling and 2 in the Terai. Several gardens were visited more than once. Field experiments were continued in representative gardens throughout the district and survey and observation plots were maintained at the branch headquarters at Nagrakata.

BUTLER'S WHARF LABORATORY

In addition to the reports of the work carried out under the direction of Tocklai, at Tocklai and in North East India, this Annual Report contains a brief account of the research work being carried out in the Indian Tea Association's Chemical Laboratory at Butler's Wharf, London. This work is mainly concerned with the chemistry of made tea and aims at the isolation of the chemical substances in made tea, the study of their formation and their relationship with the commercial characteristics of the tea. It will be seen from the detailed report that thearubigins and theaflavins are currently the main substances being studied. This work is in many ways complementary to that being carried out by the biochemical branch at Tocklai, and some aspects of the work are tackled jointly by both laboratories.

PHYSICO-CHEMICAL BRANCH

N. G. GOKHALE, Senior Physical Chemist
STAFF

The Senior Physical Chemist was on long leave during the period July to November.

RESEARCH AND EXPERIMENTS**I : Calcium economy of tea soils under prolonged S.O.A. treatment :**

While the acidifying effect of Ammonium Sulphate treatment on tea soils has been known for a long time, (for results of a recent detailed investigation see I.T.A. S.D. Annual Report, 1955, pages 21-26) precise information about its effect on the calcium status of the soil has been lacking. A detailed investigation was therefore undertaken of the soil profile to a depth of 3 ft., using the three areas of Borbhetta described in table 1 for this study. Only those plots which had received varying Ammonium Sulphate treatment were made use of in this investigation.

Table 1 : Borbhetta areas used for soil calcium investigation.

Area		Plots sampled had received S.O.A. treatment at the rates specified below					
Borbhetta	5	0,390,780, & 1170 lb. of N/acre over a period of 14 years.					
„	7	580 & 1740	„	„	„	20	„
„	45/47	0 & 1520	„	„	„	20	„

Representative soil samples were drawn from four depths, 0"-9", 9"-18", 18"-27" and 27"-36", in the usual manner, and these were then analysed for calcium content after extraction with Conc. HCl (Hall's method.) Summaries of the results obtained are quoted below :—

Borbhetta area 5 : Jat of tea Deamoolie, planted November, 1932, 4 ft. square, half the plots shaded (*Albizia chinensis* (Osbeck) Merr.) from 1942 and the other half unshaded. Nitrogen applied, as Sulphate of Ammonia, at rates 0, 30, 60 and 90 lb./acre yearly during periods 1942-45, 1947-55. Soil samples from all plots were drawn in August, 1955. The results appear in table 2.

Table 2 : Calcium content in % on dry weight, as Ca, mean for four replicated plots.

Total amount of nitrogen (as S.O.A.)** applied, lb./acre	Whether shaded	Calcium content at depth			
		0"-9"	9"-18"	18"-27"	27"-36"
0 (Control)	Shade	0.032	0.029	0.018	0.012
	No Shade	.029	.026	.015	.014
390	Shade	.031	.029	.016	.012
	No shade	.028	.027	.014	.014
780	Shade	.028	.026	.013	.010
	No shade	.028	.026	.012	.010
1170	Shade	.025	.024	.012	.008
	No shade	.022	.024	.012	.008
L. S. D. 5%*		0.004			

Borbhetta area 7 : Two jats of tea—light and dark leaf Silbhetta, planted November, 1935, $4\frac{1}{4}$ ft. triangular, whole area under shade (*A. chinensis* (Osbeck) Merr.) from 1947 onwards. Nitrogen applied, as Sulphate of Ammonia, at two levels—20 and 60 lb./acre yearly during period 1936-46 and 40 and 120 lb./acre yearly respectively during the period 1947-55. Soil samples from all plots drawn in June, 1955. The results appear in table 3.

Table 3 : Calcium content in % on dry weight, as Ca, mean for four replicated plots.

Total amount of nitrogen (as S.O.A.) applied, lb./acre	Jat of tea	Calcium content at depth			
		0"-9"	9"-18"	18"-27"	27"-36"
580	Dark leaf	0.020	0.020	0.005	0.004
	Light „	.025	.025	.008	.004
1740	Dark leaf	.012	.009	.003	.003
	Light „	.015	.010	.004	Trace
L.S.D. 5%		0.004			

*L.S.D. = Least significant difference.

**S.O.A. = Sulphate of Ammonia.

Borbhetta area 45/47 : Twelve jats of tea under trial, planted October, 1936, $4\frac{1}{2}$ ft. triangular, chosen plots are unshaded. Nitrogen applied, as Sulphate of Ammonia, at the rates 0 and 60 lb./acre yearly respectively during the period 1937-40, 43-45 and 0 and 100 lb./acre yearly respectively during period 1946-1956 (Note : oilcake was applied in lieu of S.O.A. during the years 41-42 and certain quantities of Superphosphate and Sulphate of Potash were applied in 1938 to the N treated plots ; in addition all plots were dressed with Superphosphate and Muriate or Sulphate of Potash in 1939, 1940 and 1947). Soil samples were drawn from all plots in April, 1956. The results appear in table 4.

Table 4 : Calcium content in % on dry weight, as Ca, average for 12 jats of tea.

Total amount of nitrogen (as S. O. A.) applied, lb./acre	Calcium content at depth			
	0"-9"	9"-18"	18"-27"	27"-36"
O (Control)	0.028	0.026	0.020	0.015
1520	.019	.018	.014	.014
L. S. D, 5%	0.002			

The results have also been presented in a simplified form in diagram 1. Data about the original calcium status of these three areas are not available and assuming that the different plots were initially comparable, it is apparent that S.O.A. treatment has brought about a significant reduction in the calcium content of the soil. Results of statistical analysis of the data for Borbhetta area 5 are presented in table 5. It would appear from these results that the net effect on soil calcium is directly proportional to the amount of Ammonium Sulphate applied to the soil.

Table 5 : Statistical analysis of soil calcium data for Borbhetta area 5.

				S.S. $\times 10^6$	D.F.	M.S. $\times 10^6$	F
S. O. A. treatment (N), due to linear regression				452	1	452	11.9 ** (Sig. 1%)
" " deviation from regression				22	2	11	
S. O. A. treatment (N) total ...				474	3	158	4.2 * (Sig. 5%)
Shade (S)	...	...	...	23	1	23	
N $\times$ S	...	...	...	7	3	2	
Error (1)	...	...	...	904	24	38	
Depth (D)	...	...	...	7,104	3	2,368	296 *** (Sig. 0.1%)
D $\times$ N	...	...	...	41	9	4	
D $\times$ S	...	...	...	45	3	15	
Error (2)	...	...	...	609	81	8	

Assuming that the weight of Borbhetta soil to a depth of 3 ft. is about 11 million lb. per acre, the amounts of calcium lost from the 3 ft. profile were then calculated in all the above three cases and a summary of the results obtained is given in table 6. The close agreement between the calculated values for shaded and unshaded plots respectively from three entirely different field experiments at Borbhetta may specially be noted. It is emphasised that the Conc. HCl extraction method was used for estimation of calcium and that the results quoted refer to the top 3 ft. depth of the soil only. Precise information is therefore not available about any possible losses of calcium from deeper depths through leaching or about the exact amounts which are brought up from deeper layers and added to the top soil. It should be mentioned, on the other hand, that not all the quantities shown in table 6 are lost by leaching with S.O.A. For example, a small portion of the loss, estimated at about $1\frac{1}{2}$ lb. of Calcium Carbonate in the case of unshaded tea and half that amount for shaded tea respectively, is actually due to removal of calcium in the plucked leaf. This study was confined only to calcium because the Borbhetta soil is very deficient in the other bases and preliminary leaching experiments had already shown that the predominant cation lost with Sulphate of Ammonia treatment was calcium.

It is customarily assumed that the loss of bases resulting from application of 100 lb. of Ammonium Sulphate can be made good by adding about 110 lb. of Calcium Carbonate to the soil. The results of the present investigation, however, show that the order of loss appears to be much lower under the field conditions obtaining in our tea areas.

Table 6 : Estimates of calcium lost from 3 ft. of Borbhetta soil.

Area	Shade status	Expressed as lbs. of Calcium Carbonate for every 100 lb. of S. O. A. applied
Borbhetta area 5, average	half shaded and half unshaded	25 $\pm$ 4
" " "	only shaded plots	28 $\pm$ 6
" " "	only unshaded "	22 $\pm$ 7
Borbhetta area 7, average for two jats	all plots shaded	34 $\pm$ 4
Borbhetta area 45-47 average for 12 jats	all sampled plots unshaded	23 $\pm$ 3

II : Physical analyses of soils :

Attempts have been made to measure the physical properties of soils, using for these investigations an area at Borbhetta which has been under different methods of cultivation for a number of years. The work carried out so far has been mainly exploratory, the object being to try out different methods and to standardise them so that these techniques may be used in investigations of actual field problems as and when opportunity occurs. Some of the work carried out so far is described below.

- (i) *Wet sieving*.—Using the technique of sieving under water, it was found possible to separate the different sized crumb fractions. Undisturbed samples of soil were drawn from the chosen areas and sieves of mesh sizes 1 mm. and 3 mm. were used. In the absence of a sieving machine, the sieving had to be done by hand. It is hoped to obtain a sieving machine for use in future.

(ii) *Volume weights and total pore space.*—By drawing undisturbed core samples and weighing them, volume weights of the soil were obtained and after determining the specific gravity of the soil material, the total pore space could be calculated. An area at Borbhetta where different plots have been cheeled and light hoed respectively for over 25 years gave the following results.

Table 7 : Borbhetta area 25/27 : Core samples (top 6") were drawn from all 10 plots on 15.5.56.

Soil	Method of cultivation	Number of core samples drawn	Volume weight in million lb. per acre (top 9")	Calculated total pore space %
Borbhetta loamy sand	Continuously light hoed ...	50	2.57	50.9
do.	Continuously cheeled	50	2.64	49.7
L. S. D. 5%			0.05	0.9

(iii) *Pore size distribution.*—Attempts have been made to obtain information about pore size distribution by subjecting wetted core samples to different suction pressures and measuring the amounts of water drained off. In the absence of special apparatus, it has not been possible to use tensions exceeding about 70 cms. of water. The information obtained in this range is limited and it is hoped to obtain a pressure membrane apparatus for this work.

III : Availability of different types of phosphatic fertilisers :

An attempt has been made to obtain some fundamental information about the availability of different forms of phosphatic fertilisers and the relative fixation occurring in the case of different tea soils. Four different samples of tea soils were used in this study and Superphosphate was compared with two

forms of treated rock phosphates, namely, Hyperphosphate and Agrophosphate. The procedure adopted was as follows. Given quantities of the different phosphatic fertilisers were mixed intimately with the chosen soils and the treated soils were then stored in a moist condition. Samples were drawn from these at certain intervals upto six months and analysed for phosphate content after extraction with different leaching agents. All determinations were carried out in duplicate and were corrected for the blank values. A colorimetric method was used for the estimation of phosphate. The results obtained by following the extraction procedures of Truog and Egner are presented in tables 8 and 9 respectively.

The investigation is not yet complete and certain preliminary observations only can now be recorded. It appears that a certain amount of time is necessary to bring about the maximum amount of fixation. The position at the end of six months is almost the same whatever be the type of phosphate added and the fixing capacity of different soils appears to vary. The Truog values show that Superphosphate is more easily fixed by soils, which is according to theoretical expectations, but this does not mean that the amount of phosphate available for plants would necessarily be lower. The data quoted in table 9 show that the lactate available phosphate is actually higher in the initial stages when Superphosphate is added to the soil.

It is necessary to emphasise here that the results quoted above are of theoretical interest only and deductions of practical value cannot be drawn at this stage, at any rate. In the first place it should be noted that, in this study, the fertiliser was purposely mixed thoroughly with the soil, so as to allow maximum fixation to occur. There is also the point to consider that fixation processes may be considerably modified under the field conditions obtaining in tea, on account of the special cultural practices adopted. Investigations into these practical aspects of the problem of phosphate fixation will be undertaken as and when possible.

Table 8 : Truog values of readily soluble phosphorus (extraciant used, 0.002 N Sulphuric Acid buffered at pH 3 with Ammonium Sulphate), after correction for blank values.

Soil Mark	Phosphate fertiliser added to the soil		Truog values in lb. per acre (top 9")				% phosphate unrecovered (i.e. fixed)			
	Name	Amount in lb. per acre (top 9")	Immediately after mixing	After about 2 weeks	After about 2½ months	After about 6 months	Immediately after mixing	After about 2 weeks	After about 2½ months	After about 6 months
Borbhetta (middle Assam)	Superphosphate	800	648	627	330	324	19	22	59	60
	Agrophosphate	780	684	630	404	328	12	19	48	58
	Hyperphosphate	810	814 (?)	738	446	314	0	9	45	61
Kellyden (lower Assam)	Superphosphate	800	562	419	312	372	30	48	61	54
	Agrophosphate	780	590	581	456	392	24	26	42	50
	Hyperphosphate	810	738	648	450	274	9	20	45	66
Puttabong (Darjeeling)	Superphosphate	800	423	306	234	196	47	62	71	76
	Agrophosphate	780	356	193	158	144	54	75	80	82
	Hyperphosphate	810	428	261	168	191	47	68	79	77
Bhatpara (Dooars)	Superphosphate	800	293	268	126	?	63	66	84	100
	Agrophosphate	780	594	414	371	140	24	47	52	82
	Hyperphosphate	810	643	634	430	128	21	22	47	84

Table 9 : Egner lactate values of soil phosphorus (extractant used, mixture of 90% Lactic Acid and 10% Conc. Hydrochloric Acid buffered at pH 3.7), after correction for blank values.

Soil Mark.	Phosphate fertiliser added to the soil	Egner lactate value in lbs. per acre (top 9")			% phosphate unrecovered (i.e. fixed)					
		Amount in lb. per acre (top 9")	Immediately after mixing	After about 2 weeks	After about 2½ months	After about 6 months	Immediately after mixing	After about 2 weeks	After about 2½ months	After about 6 months
Borbhetta (middle Assam)	Superphosphate	800	84	64	34	32	90	92	96	96
	Agrophosphate	780	26	28	20	21	97	96	97	97
	Hyperphosphate	810	19	49	40	38	98	94	95	95
Kellyden (lower Assam)	Superphosphate	800	57	34	25	24	93	96	97	97
	Agrophosphate	780	14	13	6	6	94	98	99	99
	Hyperphosphate	810	17	26	20	16	98	97	98	98
Puttabong (Darjeeling)	Superphosphate	800	12	8	5	4	99	99	99	100
	Agrophosphate	780	nil	3	nil	nil	100	100	100	100
	Hyperphosphate	810	nil	5	nil	nil	100	99	100	100
Bhatpara (Dooars)	Superphosphate	800	108	78	37	40	87	90	95	95
	Agrophosphate	780	30	30	23	22	96	96	97	97
	Hyperphosphate	810	67	78	40	48	92	90	95	94

IV: Chlorine uptake by the tea plant with application of Ammonium Chloride :

Advantage was taken of a field trial which has just commenced at Borbhetta, in which Ammonium Chloride is being compared with Ammonium Sulphate, to study the uptake of chlorine by tea. The fertilisers were applied to the plots on the 16th July 1956 at the rate of 80 lb. of nitrogen per acre. Leaf samples were drawn from all the plots on 14 occasions during the period May to December, 1956. The plucked shoots were brought to the laboratory and samples of bud, 1st leaf etc. were separated. The chlorine contents, for the first six dates of sampling, are given in table 10.

Table 10 : Chlorine content in tea leaf, average of five bulked samples from the replicates.

	Date of sampling	Plots	Chlorine, as Cl, % on dry weight			
			Bud	1st leaf	2nd leaf	Stem
Prior to fertiliser application	10-5-56	S.O.A. A.C.	0.022	0.032	0.042	0.042
			0.022	0.026	0.042	0.042
	24-5-56	S.O.A. A.C.	0.024	0.032	0.042	0.044
			0.022	0.032	0.042	0.042
	5-7-56	S.O.A. A.C.	0.021	0.032	0.042	0.042
			0.021	0.032	0.042	0.044
After application of fertiliser	19-7-56	S.O.A. A.C.	0.021	0.032	0.040	0.042
			0.044	0.049	0.061	0.063
	2-8-56	S.O.A. A.C.	0.023	0.032	0.044	0.046
			0.051	0.061	0.076	0.078
	16-8-56	S.O.A. A.C.	0.021	0.032	0.042	0.042
			0.070	0.080	0.099	0.102

(Note :—S. O. A. = Sulphate of Ammonia and A. C. = Ammonium Chloride).

There was little difference in the chlorine content of the leaf samples from the different plots prior to application of fertilisers. In the case of the bushes treated with Ammonium Chloride, there was, however, an immediate increase whereas the figures remained unchanged in the case of the S.O.A. treated

plots. This effect of a single application of Ammonium Chloride on chlorine uptake was noticeable right up to the end of the plucking season, as can be seen from table 11.

Table 11 : Chlorine content of 2nd leaf, expressed as Cl, % on dry weight

Date of sampling	S.O.A. series	Ammonium Chloride series
Before application of fertiliser	0.042	0.042
31. 8. 56	0.042	0.091
4. 10. 56	0.038	0.084
8. 11. 56	0.044	0.084
6. 12. 56	0.042	0.070

Although some slight symptoms were noticeable in the case of the bushes treated with Ammonium Chloride, the chlorine content did not apparently reach a toxic level in the first year of application. These tests will be continued in the following seasons.

V : Mineral deficiency symptoms :

Attempts have been made to reproduce the deficiency symptoms of N, P and K in the case of tea by using the method of sand culture. Special quartz sand was obtained for this purpose from Calcutta and the nutrient solutions used were the same as those used by workers in Java (Archief voor de Theecultuur, 15e Jaargang No. 1, 1941, page 6). Seeds were collected from the Indo-China plot No. 272A in November, 1954 and germinated in sand. The seedlings were transplanted into the culture pots in December, 1954. Nutrient solutions were applied weekly from April, 1955. There were 3 pots for each of the following series :—

Series A : received complete nutrient solution.

„ B : received all nutrients except nitrogen.

„ C : „ „ „ „ phosphorus.

„ D : „ „ „ „ potassium.

Observations on the condition of the seedlings have been recorded during the years 1955 and 1956. The symptoms exhibited by the "minus N" and the "minus K" pots were similar to those recorded by workers in Java. Further work on this subject using clonal material, if possible, is contemplated.

PUBLICATIONS

GOKHALE, N. G., "Nitrogenous fertilisers for tea", Journal of the Indian Society of Soil Science, Vol. 4, No. 3, 1956, 205-214.

GOKHALE, N. G., "The manuring problem in tea", Transactions of the 6th International Soil Congress, Paris, 1956, Commission IV, 49-52.

ADVISORY

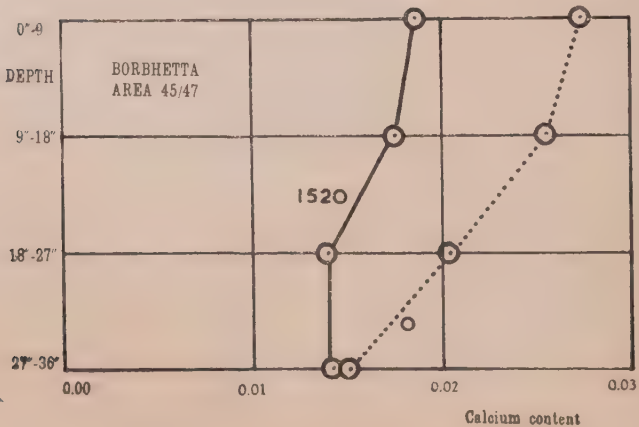
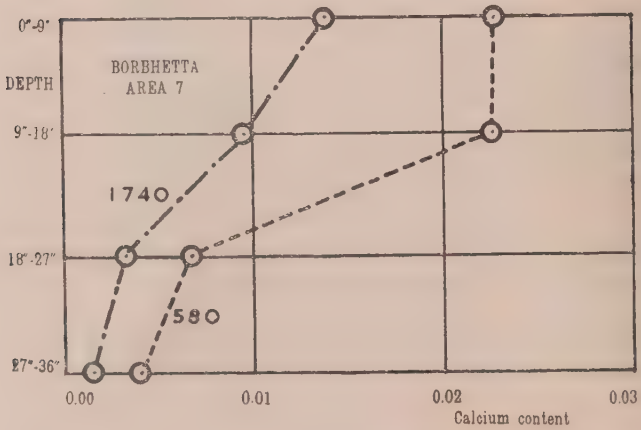
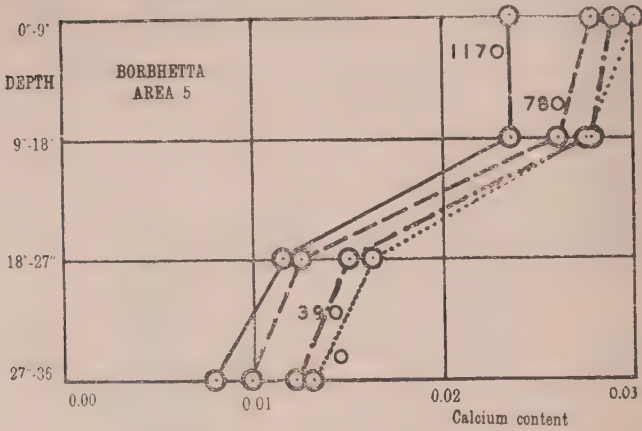
Touring.— During the year the Senior Physical Chemist paid visits to 4 gardens in the Nazira and Sonari circles.

Routine analysis.— Acidity and other routine determinations were carried out on a total of 985 soil and other samples during 1956. The soil samples examined were mainly in connection with selection of nursery sites, areas due for uprooting/replanting and suitability of virgin areas for planting tea.

Correspondence.— 214 advisory reports were issued to tea gardens and, in addition, 267 other letters were issued.

DIAGRAM 1 : EFFECT OF S.O.A. TREATMENT ON SOIL CALCIUM

Calcium, as Ca, % on dry weight



METEOROLOGICAL OBSERVATIONS

Tocklai Meteorological observations 1956 :

Table 12

Month	Mean temp. °F		Sunshine in hrs.	Rainfall in inches.	No. of rainy days.	Terrest- rial min. temp. °F.
	Max.	Min				
January ...	70.3 (71.9)	50.3 (48.4)	4.8 (5.6)	1.03 (0.88)	6 (5)	44.6
February ...	78.1 (75.3)	51.4 (52.9)	7.6 (6.1)	0.26 (1.25)	1 (7)	45.4
March ...	79.5 (81.2)	60.2 (59.6)	6.7 (6.5)	4.52 (3.80)	13 (11)	55.7
April ...	84.5 (83.2)	67.7 (65.7)	6.1 (5.7)	6.48 (7.77)	16 (17)	65.4
May ...	86.0 (86.0)	73.0 (71.0)	4.5 (5.0)	9.71 (10.66)	23 (20)	71.9
June ...	89.1 (88.9)	75.2 (75.1)	4.0 (4.5)	9.02 (12.73)	27 (23)	74.6
July ...	89.5 (90.0)	74.8 (75.9)	5.8 (4.9)	21.37 (15.08)	20 (25)	74.0
August ...	89.6 (89.8)	75.2 (75.8)	5.9 (5.1)	10.21 (13.04)	24 (23)	73.9
September	89.6 (88.2)	73.7 (74.5)	7.1 (4.9)	5.28 (10.42)	10 (19)	71.0
October ...	84.7 (84.6)	68.1 (69.3)	5.4 (5.3)	6.26 (4.70)	11 (12)	65.3
November...	79.4 (79.1)	59.4 (58.8)	6.2 (5.8)	1.43 (1.09)	5 (4)	55.1
December ...	73.3 (73.6)	49.6 (50.7)	6.2 (5.7)	0.72 (0.44)	5 (3)	44.1
Total ...				76.29 (81.66)	161 (169)	
Average ...	82.8 (82.6)	64.9 (64.8)	5.9 (5.4)			61.8

Table 13

% Relative Humidity monthly averages

Hrs. I. S. T.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec
06 13	97 (96)	95 (93)	96 (86)	94 (86)	94 (88)	92 (88)	94 (89)	95 (90)	95 (91)	97 (93)	98 (95)	98 (97)
13 13	64 (61)	48 (56)	60 (61)	66 (67)	74 (71)	73 (75)	74 (75)	74 (76)	69 (76)	75 (75)	66 (67)	63 (64)

Note :—Data in brackets show previous averages. Averages for morning observations are actually for 0700 hrs. (I. S. T.)

Table 14 : Vapour Tension (monthly averages in inches of mercury)

Hrs. I.S.T.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
06 13	0·391 (·389)	0·393 (·460)	0·544 (·554)	0·701 (·671)	0·839 (·795)	0·881 (·913)	0·907 (·933)	0·927 (·939)	0·893 (·910)	0·765 (·793)	0·560 (·585)	0·392 (·434)
13 13	0·442 (·450)	0·432 (·488)	0·555 (·587)	0·717 (·710)	0·863 (·815)	0·910 (·922)	0·931 (·949)	0·950 (·971)	0·909 (·948)	0·806 (·830)	0·627 (·640)	0·478 (·500)

Note : Data in brackets show previous averages. Averages for morning observations are actually for 0700 hrs. (I.S.T.).

Table 15: Soil Temperature °F., % Soil Moisture and Evaporation from U.S.A. Open Pan Evaporimeter and Piche Evaporimeter (monthly averages).

Month	Soil Temp. at 1 ft.				Soil Temp. at 3 ft.				% soil moisture (top 9")		Evaporation in inches (daily mean)	
	Bare		Grass		Bare		Grass		morning	after-noon	USA Open Pan (1)	Piche (2)
	at 0613	at 1313	at 0613	at 1313	at 0613	at 1313	at 0613	at 1313				
January ...	64.8 (63.4)	64.4 (64.5)	65.8 (64.0)	65.6 (64.8)	69.0 (67.6)	69.1 (68.9)	67.5 (67.2)	67.5 (67.6)	15.2	14.9	0.050	0.052
February ...	67.4 (66.3)	66.7 (67.5)	67.7 (66.5)	67.4 (67.4)	69.5 (68.2)	69.6 (69.7)	68.5 (68.2)	68.4 (68.8)	12.5	12.6	0.090	0.133
March ...	72.3 (71.5)	71.8 (72.0)	73.0 (71.8)	72.7 (72.2)	72.8 (71.5)	72.9 (72.6)	72.6 (72.2)	72.6 (72.5)	14.9	14.2	0.135	0.107
April ...	77.8 (76.3)	77.4 (76.8)	78.9 (76.8)	78.6 (77.1)	76.8 (75.4)	76.9 (75.9)	77.5 (76.6)	77.5 (76.8)	16.0	15.9	0.157	0.101
May ...	81.7 (80.1)	81.4 (81.2)	83.1 (81.1)	82.9 (81.6)	79.4 (78.5)	79.5 (78.9)	81.4 (80.4)	81.3 (80.8)	17.8	17.7	0.149	0.072
June ...	84.6 (83.0)	84.3 (84.3)	85.8 (84.6)	85.6 (85.0)	82.9 (81.9)	83.0 (81.8)	84.4 (83.9)	84.4 (84.0)	17.5	17.3	0.192	0.091
July ...	85.6 (85.7)	85.2 (85.6)	86.9 (86.5)	86.6 (86.2)	82.5 (83.9)	82.6 (83.2)	85.5 (85.7)	85.5 (85.7)	18.2	18.2	0.167	0.078
August ...	86.0 (85.8)	85.7 (86.0)	87.4 (86.7)	87.2 (86.6)	83.7 (84.5)	83.7 (84.0)	85.8 (86.1)	85.8 (86.1)	18.5	18.4	0.170	0.078
September	85.6 (84.7)	85.3 (85.3)	86.7 (85.6)	86.5 (86.0)	83.8 (84.2)	83.8 (84.2)	85.6 (85.5)	85.6 (85.7)	16.9	16.8	0.159	0.078
October ...	81.8 (80.9)	81.6 (81.4)	82.9 (81.8)	82.8 (82.4)	83.0 (82.1)	83.0 (82.7)	83.1 (82.7)	83.1 (82.8)	16.5	16.4	0.106	0.062
November ...	75.4 (73.6)	75.0 (74.8)	76.7 (75.0)	76.5 (75.8)	78.7 (77.2)	78.8 (78.5)	77.8 (77.2)	77.8 (77.5)	16.3	16.1	0.072	0.052
December ...	67.7 (66.5)	67.2 (67.8)	68.9 (67.4)	68.6 (67.8)	72.8 (71.4)	72.9 (73.0)	71.0 (70.9)	71.0 (71.3)	13.6	13.5	0.051	0.059

Note.—(1) U. S. A. Open Pan Evaporimeter installed in the meteorological enclosure—height of the rim of the evaporimeter is 14" from ground level.
 (2) Piche Evaporimeter installed inside the Stevenson Screen at a height of 4' from ground level. Values converted from ccs. to inches as per I. M. D. circulars.
 (3) Data in brackets show previous averages. Averages for morning observations are actually for 0700 hrs. (I.S.T.)

BOTANICAL BRANCH

W. WIGHT—Senior Botanist,
 M. J. GREEN—Botanist,
 D. N. BARUA—Plant Physiologist.

STAFF :

Dr. W. Wight visited the Indian Botanic Garden on the 6th and 8th March, and acted for the Director for 45 days during the year. Mr. M. J. Green visited seven, and Dr. D. N. Barua six, estates, all in the Brahmaputra (Assam) valley.

RESEARCH AND EXPERIMENT

It is convenient to consider the work of the laboratory in three sections designated Tea Breeding, Morphology and Taxonomy, and Illumination and Nutrients; though it is to be noted that this is largely a matter of administrative convenience and that the several lines of work are part of integrated research projects all associated with the production of improved seed bearing clones. In this connection one should bear in mind genetical aspects of the shade and nutrient problems outlined on pages 29 to 34 of the Annual Report for 1955. Work in connection with the Illumination and Nutrient section of the programme was undertaken by Dr. D. N. Barua (Plant Physiologist) and is described by him in this report in the form of three short articles, under this main head.

TEA BREEDING

This is a long term project, reported only in alternate years. The last report was for the year 1955.

MORPHOLOGY AND TAXONOMY

Work during the year has shown that some of the plant populations cultivated as tea are almost certainly species hybrids of which only one parent is referable to forms of *Camellia sinensis* (L.). An account of this work, entitled "What is Tea ?" is in the technical press at the time of writing (February, 1957).

Other investigations show that the entity generally known as *C. sinensis* (L.) comprises *C. sinensis* in the restricted sense (the classical tea plant of China) and two other taxa recognisable with certainty at varietal level. This work has been done jointly with the biochemical staff and is to be published by Roberts *et al* from the Association's chemical laboratory at Butler's Wharf (London).

It is to be noted that cross breeding has almost destroyed the existence of taxa as entities in the tea crop : one can (and must) suppose crop populations to be derived from taxa, but the taxa themselves are largely hypothetical. As botanical nomenclature is inseparable from the concept of a taxon, the hard and undeniable fact remains that tea populations cannot be satisfactorily defined by a nomenclatural system. Studies have been made, and are continuing into 1957, of morphological features with a simple genetical behaviour in crosses, that may provide an objective definition of populations without reference to the position or status of the population relative to the entities designated by a nomenclatural system. It is to be noted that an individual plant within a population that has no acceptable nomenclatural status, cannot in itself have acceptable nomenclatural status : for instance, to recognise var. *assamica* and also var. *sinensis* within a single tea population, would generally be wrong in principle and misleading to those unaware of the circumstances. Population is used here in the sense of the progeny of an interbreeding community or *jat*, of the tea industry.

In addition to the foregoing problems, the possibility of simplification of field trials has received attention. In the ordinary way the effects of treatment are measured as weight of pluckings, the bushes being plucked at seven day intervals over a period of not less than 30 weeks : skilled supervision is needed and this greatly restricts the use of trials in tea estates as distinct from an experimental station. Suitable measurement of the more permanent parts of the bush at comparatively infrequent intervals might give a sufficient indication of important treatment effects. No useful statement is possible in the present state of the work.

ILLUMINATION AND NUTRIENTS.

D. N. BARUA

Light Intensity, Assimilation Rate, and Yield of Young Tea Plants :

Mention was made in the Annual Report for 1955 that efforts were being made to study the behaviour of seedling populations under an experimental canopy of bamboo screens, with a view to reducing the size and duration of large scale field trials. The experiment described under this heading is the first of its kind designed to explore these possibilities and at the same time to obtain information of fundamental value. A preliminary report of this experiment appeared in the Annual Report for 1954, which includes details of the plot design and also a description of the method used for determining leaf area.

Four clones were used in the experiment, viz. :

19/36/15—Glabrous form of the Assam variety.

20/23/1 —Pubescent form of the Assam variety.

19/29/13—Heterozygous for characteristics of China variety and southern form of the Assam variety.

114/2 —Dwarf form of the China variety.

Cuttings of these clones were planted in the usual 4' × 30' type of beds at 4½" spacing, in September, 1953. Bamboo mesh screens transmitting 20%, 35%, and 50% of full light (100%) were erected over the beds when the cuttings completed their first flush. To prevent entry of unfiltered light, the sides of the nursery beds were also covered with screens of the same mesh sizes. Random samples of five plants were dug up from each plot on the day on which the screens were first erected. The plants were divided into leaves, stems, roots, and the original pieces of cutting stem. Leaf area was determined, roots were washed free of soil particles, and all the parts were dried to constant weight.

Four similar samples were drawn at successive fortnightly intervals, a total of five samples being drawn for estimation of

Net Assimilation Rates. The last sample was drawn on 14th July, 1954.

The remaining plants were pruned at the first flush banjhi horizon towards the end of 1954 and plucked during 1955, leaving 4" of new growth. Three plants in each plot were left unplucked for observing the production of laterals under different light intensities.

Soil and air temperatures were recorded every day under each light screen continuously for two years commencing mid May, 1954. Carbon dioxide concentrations and humidity were also determined on a few occasions. Soil moisture was determined once in the driest part of the year in February.

The plants remaining at the end of 1955 were again pruned leaving $\frac{1}{2}$ " of new growth and plucked till the middle of 1956, when it was decided to suspend plucking and thin out the plants to provide enough room for development for every one of the remaining plants. After thinning out, all plants were pruned $\frac{1}{2}$ " above the previous pruning level at the end of 1956.

Experimental results.—(a) *Soil and air temperatures.*—Soil temperature at 6" depth and air temperature at approx. 1' above the ground, at the level of the leaves, was recorded in the experimental plots every day at 10 a.m. and 3 p.m. for more than two years. The difference in air temperature between unshaded and shaded plots was very small, although the temperature showed a tendency to decrease with increasing shade density, while soil temperature, at times, recorded a difference of 4.5°—5.5°C.

In each year soil temperature in the open and also under the screens showed trends as illustrated by the curve in Fig. 1. These curves can conveniently be divided into four seasonal phases of unequal duration. Average daily soil temperatures at 10 a.m. and 3 p.m. (local sun time) in four different light intensities during these four phases are shown in Table 1. It is seen that the maximum temperature changes throughout the year took place in the open and the minimum under 50% light intensity. During the winter phase, soil temperature at 10 a.m. is the minimum in the open and the maximum in 50% light.

FIG. 1

SOIL TEMPERATURE AT 10 A.M. IN FULL SUN.

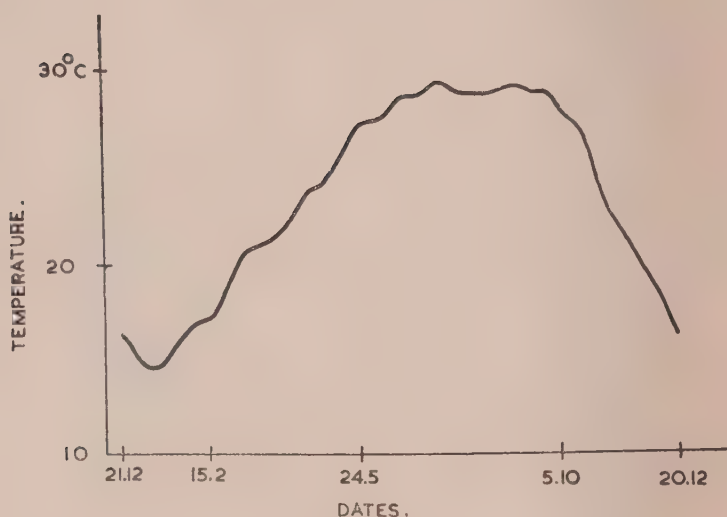


Table 1 : Average soil temperature at 6" depth in °C.

Phase.	Approx. duration in weeks.	At 10 a.m.				At 3 p.m.			
		Light intensity.				Light intensity.			
		100%	50%	35%	20%	100%	50%	35%	20%
1. 4th week of Dec. to 2nd week of Feb.	8	15.6	16.4	16.2	16.3	18.2	17.6	17.3	16.2
2. 3rd week of Feb. to 3rd week of May	14	22.2	22.1	21.8	21.2	24.5	23.3	22.9	21.7
3. 4th week of May to 1st week of Oct.	19	28.4	28.0	27.9	27.5	30.1	28.6	28.7	28.0
4. 2nd week of Oct. to 3rd week of Dec.	11	21.8	22.3	21.9	21.4	23.9	23.0	22.7	21.8

As the temperature gradually rises in the spring, the afternoon maximum is shifted towards full light, although the morning temperature remains the same under 50% and 100% light intensities.

During summer, the morning and evening temperatures are much higher in the full sun than under 50% light. When temperature starts to drop in the autumn the morning maximum is again shifted towards 50% light. Hence apart from reducing light intensity, the effect of a screen providing moderate shade is to keep the temperature more uniform throughout the year, and this presumably is a condition beneficial for the growth of tea bushes. Similar temperature conditions are likely to prevail under a tree canopy during the cropping season when the trees are bearing leaves.

(b) *Soil moisture.*

Soil moisture increases as the intensity of illumination (as measured by a Weston exposure meter) is reduced. The data in Table 2 were obtained from a set of measurements done in February, 1955, during a spell of very dry weather. They confirm observations reported by the Agricultural Branch on page 60 of the Annual Report for 1955.

Table 2

	Light intensity.			
	100% (full light)	50%	35%	20%
Percent soil moisture	10.6	11.5	12.7	12.7

(c) *Humidity and CO₂ concentrations*

No difference in these environmental factors was observed between beds under different light intensities. Any difference which might have been present would be obscured by lateral diffusion of air into the narrow 4' wide covers; hence no conclusion can be drawn from these observations as to the effect of reduction of light intensity on humidity and CO₂ concentrations.

(d) Dry weight of whole plant and leaf area.

Analysis of dry weight of all the five samples was given in the Annual Report for 1954, page 42. A similar analysis was done on leaf area. In the analysis for leaf area the interaction of light intensity $\times$ clone $\times$ sample (linear) was not significant; in all other respects, the two analyses gave identical results, *i.e.* clones and light intensities were significantly different in respect of dry weight and leaf area.

The dry weights and leaf areas of the 5th sample for clones and light intensities are given in Tables 3 and 4. In the absence of clone $\times$ light interaction, clones are summated for showing the effect of variation of light intensity and light intensities are summated for showing the variation due to clones.

Table 3 : Dry weight of the whole plant.

Effect of clones.		Effect of light intensity.	
Clone.	Dry weight per plant	Light intensity.	Dry wt. per plant
19/36/15	3.08 gm.	100% (full light)	2.24 gm.
20/23/1	2.72 "	50%	2.24 "
19/29/13	1.64 "	35%	2.02 "
114/2	1.02 "	20%	1.96 "
Difference required for P=.05 : 0.164 gm.		Difference required for P=.05 : 0.164 gm.	

Table 4 : Leaf area.

Effect of clones.		Effect of light intensity.	
Clone.	Leaf area per plant.	Light intensity.	Leaf area per plant.
19/36/15	242 cm ²	100% (full light)	142 cm ²
20/23/1	189 "	50%	167 "
19/29/13	116 "	35%	153 "
114/2	74 "	20%	159 "
Difference required for P=.05 : 11 cm ² ,		Difference required for P=.05 : 11 cm ² .	

Dry weight of the plant did not differ between 100% and 50% light intensity but fell significantly when light intensity was further reduced. Leaf area on the other hand increased significantly when light intensity was reduced from 100% to 50%. Further reduction of light intensity did not result in any more increase in leaf area.

Analysis of the dry weight of roots of the 5th sample showed clones to be significantly different but changes in illumination intensity failed to produce a significant effect on dry weight of roots within the short duration of the experiment. Nevertheless there was a tendency for root dry weight to decrease under low light. The ratio of dry weights of top/root also showed a significant variation between clones but not between light intensities. These results are presented in Table 5.

Table 5 : Weight of roots.

Clone	Dry weight of roots per plant	Top/Root ratio.
19/36/15	0.40 gm.	7.64
20/23/1	0.36 „	6.06
19/29/13	0.21 „	5.78
114/2	0.11 „	8.25
Difference required for $P=0.05 : 0.04$ gm.		Difference required for $P=0.05 : 1.52$.

The correlation between dry weights of roots and tops within a clone is highly significant and the magnitude of the correlation coefficients, which is the same for all the four clones, was not significantly altered by changes in light intensity. The average value of the correlation coefficient for the four clones and light intensities is 0.88, significant at 0.1% level of probability.

(e) Net Assimilation Rate.

Dry weight and leaf area, being in a state of constant change, are not suitable criteria for comparing different plants

or their reactions to changing environment, except when plants are strictly comparable in age. For this reason, derived relations are often used in growth studies to measure some innate characteristics of the plant. Net Assimilation Rate (N.A.R.) is one such relation which, during an active growing phase, remains more or less constant under a given set of environmental conditions. It is a measure of the capacity of plants to form dry matter per unit area of leaf surface in unit time; in other words it measures the innate efficiency of an assimilating process which is characteristic of a plant under a given set of environmental conditions. Net Assimilation Rate is expressed by the formula :

$$E = \frac{1}{L} \cdot \frac{dw}{dt} \quad \text{where } E \text{ is N.A.R., } dw \text{ is the dry weight increment in the short interval } dt, \text{ and } L \text{ is the average leaf area during the interval } dt.$$

When leaf area and dry weight increase proportionately, then the above formula can be written as :

$$E = \frac{W_2 - W_1}{t_2 - t_1} \cdot \frac{\log_e L_2 - \log_e L_1}{L_2 - L_1} \quad \text{where } W_2 \text{ and } W_1 \text{ are dry weights of the whole plants, and } L_2 \text{ and } L_1 \text{ are the leaf areas at time } t_2 \text{ and } t_1 \text{ respectively.}$$

It is to be noted in this connection that gross weight of a plant is the product of the efficiency of the assimilating process as defined by N.A.R. and its size, which is determined by the surface area of leaves. Hence N.A.R. does not necessarily bear a direct relationship to the gross weight.

Analysis of all available values of N.A.R. shows that clones differ significantly in their ability to form dry matter per unit area of leaf surface, and variation in light intensity also produces a significant effect. The interaction of light intensity and clone is not significant. In the absence of this interaction, mean values of Net Assimilation Rates are shown separately for clones and light intensities in Table 6, in grams of dry matter formed by 100 square centimeters of leaf surface in a week (gm/100 cm²/week).

Table 6 : Net Assimilation Rate.

Effect of clones.		Effect of light intensity.	
Clone.	Mean N. A. R.	Light intensity.	Mean N. A. R.
19-36-15	0.265 gm/100cm ² /week	100% (full light)	0.311 gm/100cm ² /week
20-23-1	0.232 "	50%	0.292 "
19-29-13	0.233 "	35%	0.256 "
114-2	0.344 "	20%	0.221 "
Difference required for P=0.05 : 0.076 gm/100cm ² /week		Difference required for P=0.05 : 0.064 gm/100 cm ² /week	

Of the four clones, the China clone 114/2 has the highest N.A.R., there being no significant difference between the remaining three clones. These results are suggestive, but the number of clones involved is inadequate to justify generalisation. Nevertheless it is clear that N. A. R. is a clonal characteristic. The Net Assimilation Rate increases as the light intensity is raised from 20% to 100% and the increase is linearly related to the logarithm of the light intensity. In this respect, therefore, tea follows the same rule as many species of annual plants studied by Blackman and his co-workers¹. It is to be noted that these results give great emphasis to the light intensity obtaining under a canopy.

Results given in the foregoing tables show that reduction in light intensity from 100% to 50% reduced net assimilation but caused an increase in leaf area so that there was no change in the total dry weight per plant under 50% and 100% light intensities; light intensity below 50% caused a net loss in the dry weight of the whole plant by reducing the Net Assimilation Rate, relatively more than the increase in leaf area.

It should be mentioned here that assimilation rates of the order of 0.3 gm/100 cm²/week are not uncommon amongst tropical plants under natural conditions. As low a value as 0.1 gm/100 cm²/week has also been recorded in the literature. It is of interest in this connection to compare the Net Assimilation Rates under natural conditions of three beverage plants,

coffee, cacao and tea. Goodall² obtained a value of 0.072 gm/100 cm²/week for cacao seedlings between 6 and 30 weeks from planting when growing in the field under natural shade of 18% daylight. Higher light intensity was not found to be better suited to their growth. To the writer's knowledge no such figure exists for coffee, but Nutman³ claims that the maximum observed rate of apparent assimilation of the coffee plant, under field conditions, is 4.5 mg CO₂/dm²/hr. Expressed in similar terms, the average rate of apparent assimilation of the tea plant, under field conditions, is unlikely to exceed 6.0 mg CO₂/dm²/hr.

(f) *Total weight of plucked shoots.*

In 1955, the young plants were plucked fortnightly on 17 occasions, commencing on 6th April and ending on 19th November. The fresh weight of plucked shoots and their number and the number of plants plucked were recorded at each plucking round. The average yield of plucked shoots per plant was calculated from these records and analysed statistically. The yield of plucked shoots was also analysed by the method of covariance on the number of plants per plot. The two methods led to identical conclusions *viz.* yield per plant was affected significantly by change of light intensity and also by clones. The precision of the results was, however, slightly enhanced by covariance. In the absence of a light $\times$ clone interaction, only the mean yields for light intensities and clones are shown in Table 7.

Table 7 : *Total fresh weight of plucked shoots*

Effect of clones.		Effect of light intensity.	
Clone	Total weight of plucked shoots per plant	Light intensity.	Total weight of plucked shoots per plant.
19/36/15	11.54 gm.	100% (full light)	10.67 gm.
20/23/1	15.26 "	50%	15.27 "
19/29/13	17.05 "	35%	13.02 "
114/2	5.53 "	20%	11.55 "
Difference required for P=.05 : 1.56 gm.		Difference required for P=.05 : 2.34 gm.	

Yield of plucked shoots is least in full sun and highest in 50% light. Conversion to dry weight is certain to reduce the margin of difference in the weight of plucked shoots between full light and reduced light since moisture content of shoots increases as the light intensity is reduced (see subsequent sections of this report) but the difference in fresh weight between full light and 50% light is too wide to be made non-significant by dry weight conversion; however the lesser margin of difference between 100% and 35% light intensities might cease to be significant if the results were expressed in terms of dry weight.

That the size of a plant does not necessarily indicate its cropping capacity can be seen from a comparison of Tables 3 and 7. Figure 2 further illustrates this point. Yield and total dry weight of clones 19/29/13 and 19/36/15 go in opposite directions.

Comparison of Tables 3 and 7 brings out the striking effect of full daylight on the total growth of the whole plant and on yield. *Full light had a depressing effect on yield, but did not have any such effect on total dry weight of the whole plant.* Light intensities below 50% had a depressing effect both on yield and on the dry weight of the whole plant. In this experiment 50% light intensity produced the highest yield without showing any detrimental effect on the general growth of the whole plant. These results are illustrated graphically in Fig. 3. The comparison of total growth and yield of plucked shoots is made between young plants of unequal ages, but this does not seem likely to detract from the value of the conclusions.

From these results, 50% light intensity under plains conditions can be considered as the lower limit for the optimum growth of the tea plant, but the question of an upper limit still remains open. It is conceivable that the canopy of the tea bushes themselves will be a decisive factor in determining the optimum density of an overhead canopy.

(g) Number of plucked shoots

The total number of shoots plucked per plant was analysed and the analysis shows both clones and the interaction of clones with light intensities to be significant respectively at 0.1% and

FIG. 2.

RELATIVE YIELD AND DRY WEIGHT OF THE WHOLE PLANT.

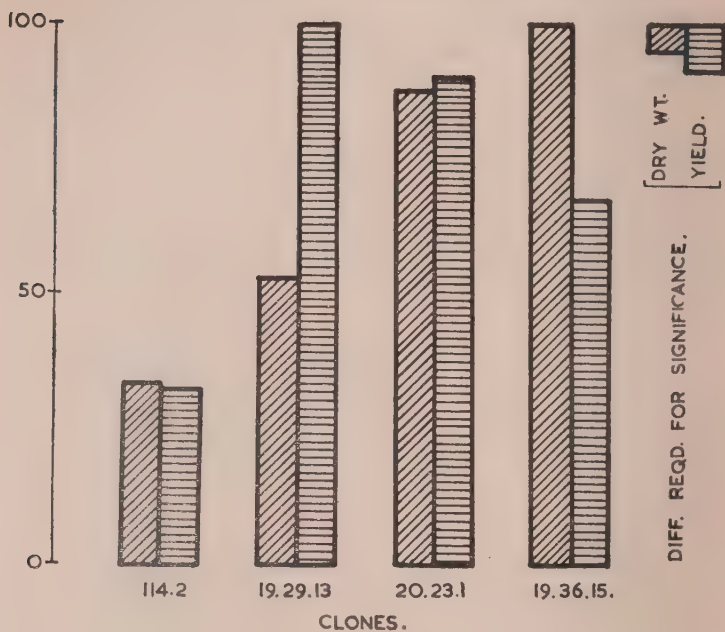
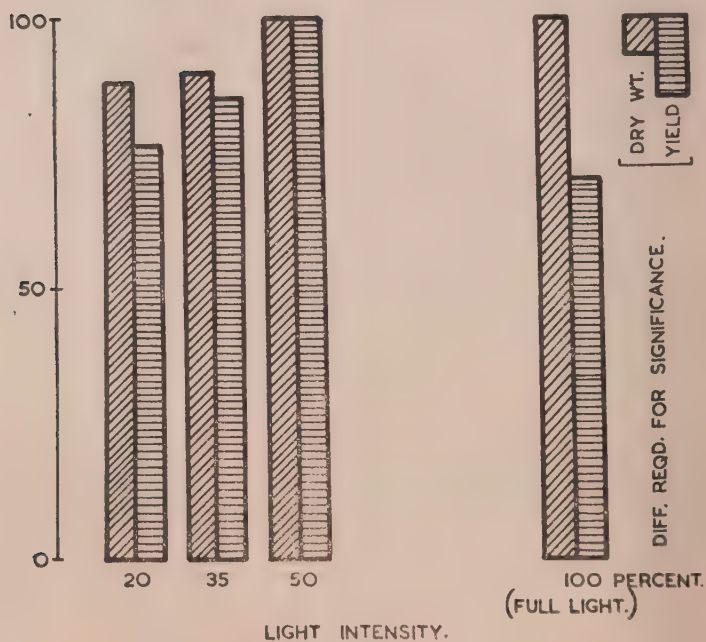


FIG. 3.

RELATIVE YIELD AND DRY WEIGHT OF THE WHOLE PLANT.



5% level of probability. Presence of the light $\times$ clone interaction made the gross effect of light non-significant. The results are given in Table 8.

Table 8 : Number of shoots plucked per plant.

Clone	Light intensity.				Clonal mean.
	100%	50%	35%	20%	
19/36/15	19.1	23.3	19.2	15.6	19.3
20/23/1	26.0	26.3	21.1	20.2	23.4
19/29/13	27.3	32.6	27.8	26.7	28.6
114/2	17.6	33.0	43.9	28.7	30.8

Difference required for $P=.05$;
 for light $\times$ clone interaction : 10.8
 for clonal mean..... : 5.4

The number of plucked shoots increases as characters of the China variety come more into prominence. The maximum number of shoots was plucked from the first three clones under 50% light intensity, whereas the maximum number of shoots was plucked from clone 114/2 under 35% light intensity. This is significantly the highest figure in the table. Full light depresses shoot production more in clone 114/2 than in the other clones. It was shown in Table 6 that clone 114/2 has the highest Net Assimilation Rate.

(h) Number of branches on unplucked bushes.

Analysis of the total number of branches on the three unplucked bushes shows, as in the case of number of plucked shoots, both clones and the clone $\times$ light interaction to be significant, respectively at 0.1% and 5% level of probability. The results are given in Table 9.

Table 9 : Number of branches per unplucked plant.

Clone	Light intensity				Clonal mean
	100%	50%	35%	20%	
19/36/15	12.4	15.6	11.5	10.0	12.4
20/23/1	15.2	14.0	15.4	15.1	14.9
19/29/13	20.9	19.0	18.1	14.6	18.1
114/2	23.5	20.6	31.8	21.4	24.3

Difference required for $P=.05$;
 for light $\times$ clone interaction : 3.1
 for clonal mean..... : 2.7

The maximum branchiness is shown by the China clone 114/2 and the minimum by the Assam clone 19/36/15.

In spite of the apparent similarity between the effects of clones and light intensities on the number of shoots on plucked bushes and branches on unplucked bushes, no relation between these two was shown by the analysis of co-variance. This suggests that the light requirements of different clones for the production of branches when they are not plucked are different from those required for the production of shoots when plucked.

The clone 114/2 from which the highest number of shoots was plucked was the poorest in total yield per plant (Table 7) while in the case of the three other clones, there exists a parallelism between total weight and total number of shoots plucked. If the area of the plucked surface were taken into account then a different picture might be obtained.

Literature cited :

- (1) Blackman, G. E. & Wilson, G. L. (1951) Ann. Bot., N. S. XV : 378.
- (2) Goodall, D. W. (1949) Ann. Bot., N. S. XIII. : 1
,, Ibid N. S. XIV. : 14
- (3) Nutman, F. J. (1937) Ann. Bot., N. S. I: 353 & 681

Permanent Parts of the Tea Bush in Relation to Light Intensity and Nitrogenous Manure :

Permanent leaves.—The number of permanent leaves below 8" tipping was counted on five different jats of tea, representing almost the entire range of jats now cultivated in the plains. The tea bushes formed part of a large trial of the effect of inorganic nitrogen as sulphate of ammonia in full sun and under moderate artificial shade, which, in this instance was approximately 50% of full sun. A leaf count was taken in full sun and under bamboo mesh screens of 50% light transmission, in the presence and absence of sulphate of ammonia. Results are given in Table 10. Each figure in the table is the average of 450 separate counts (30 bushes $\times$ 15 plucked stems per bush).

Table 10 : Average number of permanent leaves
below 8" tipping.

Jat.	Full light		50% light	
	No nitrogen	100 lb/acre nitrogen.	No nitrogen.	100 lb/acre nitrogen.
1	6.6	6.4	5.0	5.6
2	5.5	6.4	5.4	4.8
3	5.7	6.1	5.5	4.6
4	6.1	5.6	5.3	4.7
5	5.9	5.8	4.7	5.2
	5.99	6.06	5.18	4.98
Average	6.01		5.08	

Difference required for light means at $P=.05$: 0.363.

Fifty percent reduction in light intensity decreased the number of permanent leaves below 8" tipping by an average of one leaf. Neither nitrogen applied at the rate of 100 lb/acre nor the jats under observation produced an appreciable effect on the number of permanent leaves. These results show that while comparing the effect of full light and reduced light on the growth of tea bushes, use of a standard tipping measure (in inches) introduces a difference in the number of permanent leaves on the bushes in the first place : however, it has been shown that the area of a leaf increases under reduced light : whether the increase in area under 50% light intensity compensates for the decrease in the number of leaves is a matter for investigation.

Prunings.—Data for prunings were obtained from Area 8.2 (Borbhetta) where four nitrogenous manures had been applied under three light intensities, jat being constant. The experimental plots were pruned half an inch above the previous level during the first week of December, 1956. Immediately after a plot was pruned, six pruned branches collected at random from among the prunings were stripped of leaves and the fresh weight was recorded separately for the stem and the leaf portions. The leaves and stems were again weighed after drying to constant weight. The per cent dry weight of leaves and stems, calculated from these two sets of weighments, has been statistically

analysed and it is proposed to use these data for estimating the total quantity of dry matter returned to the soil in the form of prunings. Pruning weight is also a measure of increment to the permanent frame of the bush.

Results of analyses of the percent dry weight of leaves and stems are given in Tables 11 and 12. In either case, reduction of illumination intensity to less than that in full sun has decreased dry matter content. The percent dry weight of stems has also shown a significant interaction between light intensity and forms of manure. Other factors or their interactions are not significant.

Table 11 : Mean percent dry weight of leaves on the pruned branches.

<i>Light intensity.</i>		
100%	50%	40%
(Full light)		
33.8	32.8	32.5

Difference required for $P=0.05$: 0.8

Table 12 : Mean percent dry weight of stems on the pruned branches.

Kind of manure Light intensity.	Sulphate of Ammonia.	Calcium nitrate.	Urea.	Oil cake.	Light mean.
100% (full light)	31.3	33.1	34.6	32.8	32.9
50%	31.5	30.4	30.2	30.7	30.7
40%	30.5	30.4	30.7	29.7	30.3

Difference required for $P=0.05$;
for Light mean..... 0.05
for light $\times$ form of manure ... 1.55

Attention is drawn to the fact that changes in illumination intensity caused a more pronounced effect on the percent dry weight of pruned stems than on the dry weight percentages of plucked shoots (see below) or pruned leaves.

Composition of the Plucked Shoot in Relation to Light Intensity and Nitrogenous Manure :

Dry weight of the plucked shoot.—Because of the impracticability of estimating moisture in pluckings from thousands of

experimental plots at Borbhetta and in tea estates, it has been the practice at this station to analyse field experiments on the basis of fresh weight of plucked shoots. The question, however, arises whether conclusions based on the fresh weight of plucked shoots can be modified appreciably by conversion to dry weight, especially in experiments involving such treatments as are likely to affect the moisture status of plucked shoots.

Data bearing on this question were obtained from Area 8.2 (Borbhetta) where four different forms of nitrogenous fertilisers in two doses have been applied under three different light intensities. The dry weight of shoots plucked from the 96 experimental plots of this area was determined on twenty four successive plucking rounds in 1956. The deviation of the percent dry weight of pluckings from the overall mean of 21.0% did not normally exceed $\pm 1.5\%$, but on 31st July and 21st August which were wet, rainy days the deviations in some instances were as high as $\pm 3.0\%$. It will be sometime before the two analyses, one based on fresh and the other on dry weight of plucked shoots, are ready for comparison; meanwhile the analysis of percent dry weight of plucked shoots has been completed and it shows that:

- (a) The gross effect of light intensity on percent dry weight of plucked shoots is highly significant ($P < 0.001$).
- (b) Interactions of doses and light intensities and doses and forms are significant respectively at 5% and 1% levels of probability.

The significant results are presented below. Table 13 shows the effect of light intensity and the interaction of light intensity with doses of N.

Table 13 : Mean percent dry weight of plucked shoots.

Doses of N.	Light intensity.			
	100% (full light)	50%	40%	
75 lb/acre	21.65	20.78	20.62	Diff. required for $P=0.05 : 0.14$
150 lb/acre	21.75	20.59	20.72	
Mean for light intensity.	21.70	20.66	20.67	Diff. required for $P=0.05 : 0.16$

Full light significantly ($P < 0.001$) increased the per cent dry weight of plucked shoots over reduced light, there being no difference between the two shades densities.

The higher *i.e.* 150 lb. dose of N tended to increase dry matter content of plucked shoots except under the lighter shade, where the percent dry matter decreased with the 150 lb. dose of applied nitrogen.

Table 14 shows the interaction of the forms and doses of nitrogen.

Table 14 : Mean percent dry weight of plucked shoots.

Dose of N.	Forms of manures.			
	Sulphate of ammonia.	Calcium nitrate.	Urea.	Oil cake.
75 lb/acre	21.01	21.01	21.09	20.89
150 lb/acre	21.14	21.08	20.87	20.99

Difference required for $P=0.05$: 0.16

In case of urea, the higher dose of N reduced percent dry weight of plucked shoots ; with all the three remaining forms of nitrogen, percent dry weight showed a tendency to increase as the dose of nitrogen was raised from 75 lb. to 150 lb.

Nitrogen fractions of the plucked shoot.—Samples of shoots plucked on three consecutive rounds from Area 8.2 (Borbhetta) during end May and early June, 1956 were dried at $85^{\circ} - 90^{\circ}\text{C}$ in a blast of hot air and dried leaves from the three plucking rounds were bulked. The bulked, powdered samples of dried leaves were analysed for total nitrogen, water soluble nitrogen and caffeine nitrogen. The total insoluble nitrogen and soluble non-caffeine nitrogen (subsequently called 'other nitrogen') was estimated by difference. Statistical analysis of the results shows :

- (a) Total nitrogen expressed as percent dry weight of leaf is increased when the light intensity is reduced below full day light. Neither the forms and doses of the four different nitrogenous fertilisers nor their interactions with light intensity are significant.

- (b) The percentage of insoluble protein nitrogen remains unaffected by change in light intensity.
- (c) The increase in the percentage of total nitrogen under reduced light is caused by a rise in the percentages of both caffeine and other nitrogen in the water soluble fraction.
- (d) As in the case of total nitrogen, forms of manure, doses and their interactions with light intensity do not have a significant effect on insoluble nitrogen nor on caffeine, but the percentage of other nitrogen goes up as the dose of applied nitrogen is raised from 75 lb. to 150 lb. N per acre. The results are given in Tables 15 and 16.

Table 15 : Percent nitrogen on dry weight.

Light intensity.	Total N.	Insoluble N.	Caffeine N.	Other N.
100% (Full light)	4.464	2.341	1.257	0.867
50%	4.622	2.366	1.322	0.934
40%	4.629	2.371	1.338	0.920
Diff. required for $P=0.05$	0.142	Not significant	0.061	0.053

Table 16

<i>Dose of applied Nitrogen.</i>	<i>Percent 'other N'</i>
75 lb/acre.	0.892
150 lb/acre	0.921
Diff. required for $P=0.05$:	0.022

It is of interest to note that a simultaneous rise in the percentage of 'other nitrogen' and of caffeine in the water soluble fraction during withering of tea leaf was recorded by the Biochemical Branch on page 111—113 of the Annual Report of the Station for 1955. Confirmation of the results in Tables 15 & 16 will be necessary by further chemical analysis.

PUBLICATIONS

The following and scientific papers were published :

Barua, D. N. Calcium oxalate crystals as an index of nutrient uptake in the tea plant. *Current Sci.*, 25(8) : 249-250.

Wight, W. Commercial selection and breeding of tea in India. *World Crops*, 8(7) : 263-268.

Barua, P. K. Wilson's Camellia, *Camellian*, 7(4) : 18-20.

Wight, W.
and

Dutta, K. N. The practical basis of high yielding tea. *Tea Trade and Industry*, 5(12) : 675-77.

ADVISORY

Sixty letters and memoranda were issued during the year, mainly to other institutes in connection with the research programme. Visits to tea gardens by members of the branch staff have been mentioned above.

AGRICULTURAL BRANCH

S. K. DUTTA—Senior Agriculturist.

S. BASU—Assistant Agriculturist.

STAFF

Mr. H. Mitra, Assistant Advisory Officer, was in training in this branch from 9th January, 1956 to 31st August, 1956. Messrs. D. J. Gray and W. J. Grice, Advisory Officers, joined this branch on the 24th September, 1956 for a period of training.

Messrs. A. P. Talukdar and D. K. Duara joined as Junior Technical Assistants on the 16th March, 1956. Mr. B. C. Borpuzari was appointed as a Junior Non-Technical Assistant on the 1st January, 1956. Mr. S. Ahmed joined as a Provident Fund Clerk in the Junior Non-Technical Assistant grade on the 14th May, 1956.

Mr. S. N. Mahanta was appointed as a Full Time School Teacher at Borbhetta on the 1st May, 1956. Mrs. M. Bhattacharjee was appointed as a Midwife and Nurse on the 1st April, 1956.

RESEARCH AND EXPERIMENTS

Introduction

All long and short term experiments were continued during 1956. It is not possible to report on each of these experiments each year. In all 33 full scale field experiments were in progress during the year, dealing mainly with problems of manuring, shade, pruning and plucking. A number of demonstration plots, and old experiments retained as demonstrations, were also maintained. Details of the findings in a few of the experiments are given in this report.

These indicate that under Borbhetta conditions phosphate and potash have once again failed to produce any effect on the yield of mature tea and on the valuation of the made teas. It has also been shown that the maximum yield is obtained only when sulphate of ammonia is applied to all the tea bushes under *Dalbergia assamica* shade trees. In a pruning experiment,

it has been demonstrated that, if pruned at a certain time, bushes can suffer severely from sun-scorch. In another experiment it has been demonstrated that an N. P. K. manure mixture applied after a medium prune and when 3 leaves have formed, is beneficial. A manure mixture for a young bamboo bari is recommended.

Various green crops, ground cover crops and new species of shade trees are being tried. We are now in a position to recommend for trial *Crotalaria grahamiana* and *Desmodium gyroides* as green crops. *Stylosanthes guyanensis* var. *gracilis* is already being used fairly widely as a ground cover crop and now we can also recommend *Calopogonium mucunoides* in non tea areas as a ground cover crop in uprooted areas, old nursery sites etc. It must NOT be grown in tea areas owing to its twining habit.

Time of Planting, Planting Method, Spacing, Planting Material, Clone and Source of Seed.—Expt. B.9C/14.

This is a complex factorial experiment designed by Mr. K. N. Dutta, with six series of treatment. The treatment series are as follows :—

Treatment Series

1. *Time of Planting :*

2nd. half of September (except in the case of seed at stake). —(T_1)

Early November/December (T_2)

End of January (T_3)

Early March (T_4)

Middle of May (T_5)

2. *Planting Method :*

Bheti (*i.e.* young plants with a ball of earth round the roots).

Carrot (*i.e.* young plants without a ball of earth round the roots).

Seed at stake (for *jats* only).

3. *Spacing* :

1' × 5' (carrot and seed at stake planting)

2' × 5' („ „ „ „ „)

4' × 5' (*Bheti* and seed at stake planting)4. *Clone* :

Light leaf Assam ... 20.17. 5 (1)

Dark leaf Manipuri ... 1. 3.14 (2)

China hybrid ... 14. 5.35 (3)

5. *Planting Material* :

1 year old clonal plant.

1 year old seedlings.

Seed.

6. *Source of Seed (Jats)* :

Light leaf Assam jat. (1)

Dark leaf Manipuri jat (2)

China hybrid (3)

The apparent effect of any one treatment or interaction is therefore an overall effect under all the conditions of the other treatment series unless these are mutually exclusive. Corresponding clones and jats have been chosen to represent three different types of tea, so that though responses on clones and jats are not strictly comparable, such comparisons can in this case be considered valid. Such overall effects are interesting and important, but must be used with caution since under any specific conditions they may fail to describe the true result to be expected.

No infilling was carried out and the treatments are exercising their effect largely through the number of bushes which have survived. The percentage survival in the different plots ranges from 0 to 100% and this is the main reason why

the yield differences five years after planting vary so greatly. The correlation is illustrated in Table I.

Table 1 : Correlation of yield of fresh leaf and percent survivors.

Time	Yield in 1955 in ozs. per plot.	% Survival (1956)
Second half September ...	100.50	75.36
November/December ...	73.31	53.22
End January ...	77.05	63.16
End March ...	65.96	51.07
Middle of May ...	52.73	39.29

Correlation coefficient $r = +0.9759^{**}$

Table 2 gives the average yield per plot in ounces, and is given for reference when considering the conclusions drawn from the experiment.

Overall Effect of Time of Planting.— September is the best time. The yields from the later plantings declined, reaching a minimum in May.

Overall Effect of Planting Materials.— The yield differences are very pronounced. Seed at stake has given more than double the yield of either seedlings or cuttings, the yields from which are almost identical. It should be noted however, that in this experiment only germinated seed was used for seed at stake planting and has resulted in a very high percentage survival. Furthermore, the difficulties associated with cultural operations are always great with seed planted at stake.

Response of the Different kinds of Tea to the Treatments. —(a) The source of seed has exerted a marked effect on the yields only when the seeds were sown at stake. The dark leaf Manipuri produced the highest yield and the China hybrid the lowest ; the light leaf Assam being intermediate. Source did not show any effect when planted with seedlings or clonal plants.

(b) The responses of the three types of tea to different planting times also depend on whether seed at stake or seed-

Table 2 : Average yield per plot in ozs. fresh leaf for 1955.

Time	Spacing	Cuttings-Bheti			Cuttings-Carrot			Seed at Stake			Seedlings-Bheti			Seedlings-Carrot			TOTAL	Ave- rage
		Clone			Clone			Jat			Jat			Jat				
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3		
T ₁ (Sep.)	1' x 5'				163.3	132.3	145.0							147.0	79.3	101.3	768.2	128.0
	2' x 5'				87.0	102.0	99.3							77.0	84.3	90.7	540.3	90.0
	4' x 5'	84.3	80.7	40.3				89.0	127.0	79.0							500.3	83.4
T ₂ (Nov.)	1' x 5'				21.3	6.7	8.3	165.3	186.3	93.3				0	0	9.0	490.2	54.5
	2' x 5'				0	8.7	5.7	166.0	189.7	87.0				2.0	2.7	7.3	469.1	52.1
	4' x 5'	140.3	105.7	73.0				125.0	129.7	72.7	159.3	138.7	75.7				1020.1	113.3
T ₃ (Jan.)	1' x 5'				23.7	49.0	102.0	177.7	203.7	142.7				29.0	50.3	97.0	875.1	97.2
	2' x 5'				24.3	36.3	75.0	125.3	159.0	76.7				5.3	17.0	66.0	584.9	65.0
	4' x 5'	71.7	99.7	37.0				66.0	93.3	51.0	62.7	79.0	60.3				620.7	69.0
T ₄ (Mar.)	1' x 5'				17.7	19.3	44.0	155.3	190.3	114.0				17.3	0	92.0	649.9	72.2
	2' x 5'				7.0	8.0	18.0	155.3	154.7	77.3				0	5.7	36.3	462.3	51.4
	4' x 5'	23.0	52.7	47.7				97.7	130.7	50.3	59.3	123.3	84.0				668.3	74.3
T ₅ (May)	1' x 5'				7.3	0	25.7	127.3	232.3	25.0				0	0	8.7	426.3	47.4
	2' x 5'				0	0	4.3	132.7	172.7	51.0				0	0	12.3	373.0	41.4
	4' x 5'	77.7	52.3	41.0				83.3	117.7	17.3	97.0	82.0	56.0				624.3	69.4
Total		397.0	391.1	239.0	351.6	362.3	527.3	1576.9	1960.1	858.3	467.3	550.0	355.0	277.6	239.3	520.6		
Average		79.4	78.2	47.8	35.2	36.2	52.7	131.4	163.3	71.5	93.5	110.0	71.0	27.8	23.9	52.1		

lings were planted. Seed was not available for September sowing, but at each of the other four times the dark leaf Manipuri produced the highest yield, and the China hybrid was consistently poor. In the case of seedlings, yield differences were not significant in the September and November plantings, but in the adverse planting months of January and March, the China hybrid plants proved more successful than the light leaf Assam. A similar effect was observed in the yields of the three clones.

(c) Differences in the three jats have also been noted in their response to the different methods of planting. In seed sown at stake, the dark leaf Manipuri gave the highest yield, the light leaf Assam gave significantly less yield, and China hybrid the least. Similarly in the case of *Bheti* planted seedlings, the dark leaf Manipuri and light leaf Assam were the most successful, but in the more rigorous method of carrot planting, the hardier China hybrid plants produced a greater crop than the other two jats. The three clones showed the same responses to method of planting—the dark leaf Manipuri and light leaf Assam clones gave the highest yield when *Bheti* planted, but proved inferior to China hybrid when carrot planted.

The effect of Sources of Plants on time of planting and Method of Planting.— (a) For the most part the clonal plants behaved similarly at the different times of planting; the highest yields being obtained in all three clones from September planting. Later plantings on the whole showed a more or less steady decline in yield, except in the case of the China hybrid clone, where planting as late as January gave equally good result.

(b) September is also the best month for planting seedlings of all three jats. In the case of China hybrid seedlings January and March plantings gave equally good results.

(c) For seed at stake planting, seed was not available for sowing in September. The yields obtained from the other times depend on the jat. November is a better month than January or May for sowing light leaf Assam jats. Dark leaf Manipuri jats can be sown with equal success from November to May, but China hybrid jats should not be sown later than March.

(d) The different methods of planting produced different results according to the date at which the operation was carried out. September carrot planting gave by far the highest yield and January the next best. November is apparently the best month for *bheti* planting, particularly for light leaf Assam jats. For seed sown at stake planting, any time between November and March is preferable to May but it must be remembered that in practice, seed deterioration in storage increases as time advances.

(e) The overall effects of planting method is quite clear in this experiment; the yield differences being highly significant in each case. Seed at stake produced the highest yield, *bheti* plants the next highest and carrot plants the lowest. In commercial practice, however, tea can only be successfully raised from seed at stake under ideal conditions.

N.P.K. Manuring on Young Assam and China types of Tea—Expt. B. 25/27.

This multilevel N.P.K. experiment was started in 1954 on young Assam (Betjan) and China (Lingia) jats of tea. The treatments are three levels of nitrogen and four levels of phosphate and potash and their possible combinations. The levels per acre are as follows :—

Nitrogen	Phosphate	Potash
0 lb. N	0 lb. P_2O_5	0 lb. K_2O
40 lb. „	20 lb. „	20 lb. „
80 lb. „	40 lb. „	40 lb. „
—	80 lb. „	80 lb. „

There are 48 different treatment combinations and 2 replicates.

1956 crop yields showed significant results only in the case of overall effect of nitrogen. In the Assam jat, the three levels of

nitrogen were significantly different from one another, the higher level yielding higher crop. In the China jat 80 lbs. N failed to yield significantly more than 40 lbs. N, although both yielded significantly more than no nitrogen.

Table 3 : Overall effect of Nitrogen—1956.

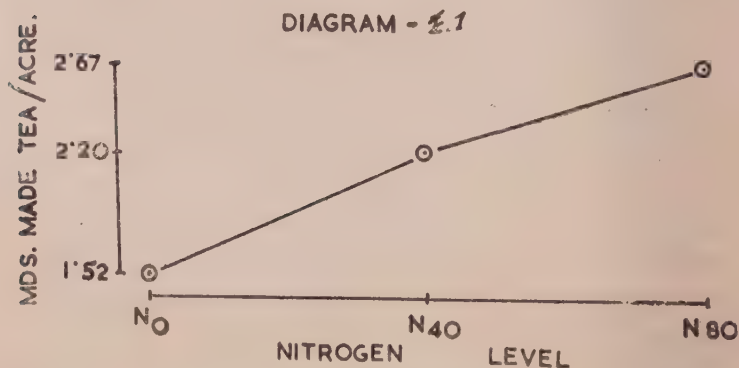
(Yield of made tea in maunds per acre.)

Jat	0 lb. Nitrogen	40 lbs. Nitrogen	80 lbs. Nitrogen
Assam	2.15	3.12	3.88
China	0.88	1.28	1.45
^{2'6"} Average	1.52	2.20	2.67

Significant difference at 5% level = 0.37

N.B.—Unless otherwise stated “yield of made tea” per acre is estimated from yield of fresh leaf assuming that 100 lbs. of green leaf makes 22.5 lbs. of made teas.

As seen from Diagram 1, the average response to the second 40 lbs. of N is only slightly less than to the first.



From the results of the last two years it appears as would be expected in young tea that in both Assam and China types the responses are cumulative. The following table illustrates this.

Table 4 : Increase due to 40 lbs. and 80 lbs. N per acre. over no Nitrogen.

	ASSAM JAT				CHINA JAT			
	1955		1956		1955		1956	
	mds. per acre	%	mds. per acre	%	mds. per acre	%	mds. per acre	%
N ₄₀	0.27	17	0.97	45	0.18	17	0.40	45
N ₈₀	0.41	26	1.73	80	0.17	16	0.57	65

Liquor and Dry tea characters on Taster's reports.— Leaf samples from all plots of the Assam and China kinds of tea were manufactured separately using Pizey rollers in alternate weeks from early June to end of October. Samples of the made teas were tasted by our Tocklai Taster and nine attributes of the liquor and dry tea were statistically analysed to see whether any of the manurial treatments had any effect on quality in either type of tea. In all the attributes, except colour of dry tea, the Assam jat was shown to be significantly better than the China jat. It must, however, be clearly understood that this may apply only in the case of these two particular areas of tea.

(i) *Quantity of Tip.*—The interaction of jats and phosphate has been significant at 5% level. The China jat produces more tip with increasing doses of phosphate, but the Assam jat produces less tip with increasing doses of phosphate.

(ii) *Colour of Tip.*—The colour of tip has not been affected by any of the manuring treatments.

(iii) *Colour of Dry Leaf.*—This has not been affected by any of manurial treatments.

(iv) *Colour of Infused Leaf.*—This has not been affected by any of the manurial treatments.

(v) *Colour of Liquor*.—The Taster's evaluations averaged for nitrogen treatments in score marks have been as follows :—

Table 5 : Taster's Scores.

(Total of 108 scorings)

80 lbs. Nitrogen	40 lbs. Nitrogen	No Nitrogen
2350	2030	1930

Significant Difference required at 5% level is 330

These figures show that the difference between 0 and 80 lbs. nitrogen is significant, the difference between other levels of nitrogen is not significant.

With regard to phosphate application of either 40 lbs. or 80 lbs. per acre did not significantly affect the colour of the liquor as compared with no phosphate.

(vi) *Strength of Liquor*.—Application of phosphate produced significant improvements in strength as can be seen from the following taster's scores :—

Table 6 : Taster's Scores.

(Total of 108 scorings)

80 lbs. P_2O_5	40 lbs. P_2O_5	No P_2O_5
2820	2510	2260

Significant Difference required at 5% level is 398

Application of phosphate at 80 lbs. per acre has significantly increased the strength of liquor over teas made from plots not receiving any phosphate. There were no significant differences between phosphate at 80 lbs. and 40 lbs. or between no phosphate and 40 lbs. per acre.

(vii) *Quality*.—Manurial treatments have had no effects on the quality.

(viii) *Briskness*.—The nitrogen-potash interaction was significant at 5% level as can be seen from the following table:—

Table 7

Potash Nitrogen	K ₀	K ₄₀	K ₈₀
N ₀	1841	1822	2062
N ₄₀	2112	1022	1890
N ₈₀	1845	1954	1846

Significant Difference required at 5% level is 212.

It will be seen that in this particular instance, in the absence of nitrogen, 80 lbs. of potash per acre has produced significantly more briskness than either 40 lbs. or no potash. In the presence of 40 lbs. of nitrogen, 80 lbs. of potash reduces briskness significantly, there being no difference between no potash and 40 lbs. potash or between 40 lbs. potash and 80 lbs. potash. In the presence of 80 lbs. nitrogen per acre, there is no significant difference between the three levels of potash.

(ix) *Valuations*.—None of the manurial treatments have produced any difference in valuations.

N.P.K. Manuring on Mature Tea.—Expt. B. 11.2 :

The experiment consists of two parts. The first part is a 3×3 factorial and completely orthogonal with blocks. This part is first split for three levels of nitrogen—0 lb., 40 lbs., and 80 lbs. per acre and then 9 combinations of phosphate and potash at 0 lb., 40 lbs. and 80 lbs. are imposed at random on each whole plot.

The second part of the experiment is non-factorial with N₀ and N₄₀ since 20 lbs. of phosphate and potash have been introduced with N₈₀ only. This part consists of 16 treatment combinations of 4 levels of phosphate and 4 levels of potash each occurring with N₈₀ and the treatments are orthogonal with blocks.

The tea under experiment is of an Assam kind and was planted $4\frac{1}{2}' \times 4\frac{1}{2}'$ triangular in 1928. The experiment was

started in 1954. Preliminary yields were taken till the end of June in 1954, and manures were applied immediately after it.

Direct Effects.— The overall effect of nitrogen was significant every year and with an increase in the level of nitrogen, there was a significant increase in the yield. The results of the last three years are given in Table Nos. 8 & 9 below.

It can be seen that the increases obtained from nitrogen application are linear. The cumulative effect of nitrogen is also clearly noticeable in the results of the above three years. The yields from no nitrogen plots are practically the same every year whereas there is a progressive increase in yield from nitrogen plots.

The overall effect of phosphate and potash was not significant except in 1955 when P_{80} gave a significantly higher yield than P_0 .

Table 8 : Yields in mds. made tea per acre.

Year Year Manure	1954 (From July to end of season)	1955	1956
N_0	5.51	6.13	6.42
N_{40}	6.53	8.00	9.05
N_{80}	7.40	10.65	11.74
S.D. at 5%	0.68	1.68	1.90

Table 9 : Percentage increase due to nitrogen treatments.

Year Year Manure	1954 (From July to end of season)	1955	1956
40 lbs. N	18%	30%	40%
80 lbs. N	34%	73%	83%

Interaction.— Significant results have so far been obtained only in the first year of the experiment *i.e.* in 1954. In this year NPK and NK interactions were significant.

Table 10 : Increase or decrease in mds. made tea per acre due to manuring with NPK combinations over $N_0K_0P_0$ —1954.

P & K N	P_0			P_{40}			P_{80}		
	K_0	K_{40}	K_{80}	K_0	K_{40}	K_{80}	K_0	K_{40}	K_{80}
N_0	0	-0.93	-0.70	-0.93	-0.17	+0.18	-0.29	+0.64	-0.30
N_{40}	+0.69	+0.99	+0.87	+1.11	+0.64	+0.82	+0.29	+0.23	+0.99
N_{80}	+1.45	+1.63	+1.11	+1.63	+1.57	+1.22	+2.85	+2.62	+0.41

Significant Difference required at 5% level is:— ± 1.14 .

The above table shows that N_{80} and P_{80} in absence of K produced the highest yield. But the presence of K_{40} tended to decrease the yield and the decrease was significant in presence of K_{80} . The depressing effect of potash was also seen in NK interaction where N_{80} alone gave significantly higher yield than $N_{80}K_{80}$. The 20 lbs. level of either P or K in combination with 80 lbs. N produced no significant result in any year.

Discussion.— The experiment has been started only recently, hence no definite conclusions can be drawn at the present moment. However, like all other NPK experiments at Borbhetta on mature tea, this experiment also shows that under Borbhetta conditions, only nitrogen gives significantly higher yield. With the increase in nitrogen (from 40 to 80 lbs.) a proportionate increase in yield has been obtained every year. The progressive percentage increase of yield by 40 lbs. and 80 lbs. N over no nitrogen in three consecutive years can partly be attributed to the residual effect of sulphate of ammonia.

As regards the effects of P and K and NPK interaction, nothing consistent has been observed. But it appears that whereas 80 lbs. of P shows a positive effect with 80 lbs. of nitrogen, a similar dose of potash gives a negative effect.

Positioning of Manures under Shade Trees.—Expt. Gar. T.E.1 :

In order to ascertain whether nitrogenous manures applied to tea under shade have the same efficiency on the bushes nearer the trunk of the tree as on the tea bushes away from the trunk of the tree, one experiment was started in a nearby tea estate, as no suitable area of well shaded non-experimental tea was available at Borbhetta.

In the Quarterly Report for the quarter ending 30th June 1950, on the basis of another experiment at Borbhetta, it was stated that “with an insufficient supply of manure the potential loss will be cut to the minimum by manuring the less shaded and omitting to manure the more shaded tea bushes ; *but failure to manure all the bushes will involve some loss in yield with shade of the density under which those observations were made.*”

The present experiment was started in 1953 in a section of tea under good mature *Dalbergia assamica* shade planted at 36 ft. $\times$ 36 ft. triangular. The tea was planted in 1927 at $4\frac{1}{2}$ ft. $\times$ $4\frac{1}{2}$ ft. triangular. Each plot has the shade tree in the middle and contains 54 tea bushes.

The following four treatments are in a randomised block layout in four repeats:—

Treatments

- 1.—No manure in the whole plot.
- 2.—Inner area of two rows of tea bushes manured (*i.e.* nearest the shade trees) @ 80 lbs. nitrogen per acre in the applied area.
- 3.—Whole plot manure @ 80 lbs. of nitrogen per acre.
- 4.—Outer area of two rows of tea bushes manured @ 80 lbs. nitrogen per acre in the applied area. (*i.e.* away from the shade trees).

In 1955, preliminary yield was taken upto the end of the second flush and manures were applied on 1st July. In 1956, the manures were applied on the 20th March. Crop records

have been kept and the results of the last two years have been as follows:—

Table 11 : Yield in maunds made tea per acre.

No.	Treatment	1955 from July only	1956 Whole season
1	No manure in whole plot (Check)	12.84	15.71
2	Inner area only manured	14.19	18.15
3	Whole plot manured	15.47	19.65
4	Outer area only manured	14.02	16.98
Significant difference required		1.18 $P < .01$	2.57 $P = .05$

In 1955, Treatments 2, 3 and 4 gave significantly higher yields than the Check. Treatment 3, where the whole plot was manured, produced significantly higher yields than all the other treatments. There was no significant difference between Treatments 2 and 4.

In 1956, Treatment 3 produced significantly higher yields than Treatments 4 and 1. There was no significant difference between Treatments 3 and 2. Treatments 2, 4 and 1 also did not produce any significant difference.

The order of yield during the two years has been as follows:—

Table 12 : Order of Yield.

Year	Treatment 3	Treatment 2	Treatment 4	Treatment 1
1955	15.47	14.19	14.02	12.84
1956	19.65	18.15	16.98	15.71
Total	35.12	32.34	31.00	28.55

The heights and girths at breast height of all the trees were recorded on 3rd November, 1955 and observations will be taken

at the end of the 3rd year, to see whether the treatments have had any effects on the growth of the trees.

The last two years results show that the maximum yield is obtained only when all the bushes under the shade trees are manured. *These results apply to Dalbergia assamica and may not apply to other shade trees.*

Effect of Artificial Shade and Manure.—Expt. B. 8.3 :

In Area No. 8.3 Borbhetta, 4 types of nitrogenous manures (Mustard Oilcake, Sulphate of Ammonia, Calcium Nitrate and Urea) are being compared under 3 different light intensities. After changing of the bamboo screens in 1955/56 cold weather, the light intensities under the screens are 50% and 40% instead of 70% and 50% (Ref. 1955 Annual Report), as measured by a Weston Master II exposure meter.

The differences that appeared in the 3rd and 4th year, from the results of the first two years have continued to be the same in the fifth year.

Table 13: Yield in mds. made tea per acre.

YEAR					
Light Intensity	1952	1953	1954	1955	1956
100%	6.35	9.39	11.77	12.98	15.14
70%	8.53	12.13	13.24	12.99	15.32*
50%	8.18	11.19	12.51	12.18	14.46*
S. D. required	1.62 (P = .01)	1.23 (P = .01)	1.38 (P = .05)		1.59 (P = .05)

*Light intensities were 50% and 40% instead of 70% and 50% respectively.

In the 3rd year for the first time the gross effect of 70% light provided by artificial shade failed to be significant over no shade and this was also the case in the fourth and fifth year and actually there is a slight indication that the 50% light is depressing the yield. The 70% light maintained its significantly higher yields until the third year, but in the fourth year it failed to show any significant increase over 100% light. In the fifth year, yield under 50% light is still higher than in full light or the heaviest shade.

Two things, however, should be borne in mind :—

- (a) The shade of both the shade densities is fairly high.
- (b) The shade provided by the bamboo screens is continuous throughout the year and is therefore, unlike that provided by most shade trees at present grown in North East India.

In the first year of the experiment the different forms of manure did not show any difference in effect nor did the different rates of application.

In the second year sulphate of ammonia produced significantly higher yields than Calcium Nitrate and Urea, but it did not produce higher yields than Oilcake. 150 lbs. nitrogen per acre gave significantly higher yields than 75 lbs. nitrogen in the cases of Oilcake and Sulphate of Ammonia only.

Table 14: Yield in mds. made tea per acre.

YEAR,		1952		1953		1954		1955		1956	
Manure	Dose	Mean		Mean		Mean		Mean		Mean	
	Lb.										
Oilcake	75	7.12	7.50	10.06	11.08	11.67	12.84	12.05	13.38	14.41	15.82
	150	7.89		12.10		14.01		14.71		17.22	
Sulphate of Ammonia	75	7.89	7.86	11.01	11.58	12.35	13.20	12.35	13.03	14.03	14.80
	150	7.83		12.16		14.06		13.71		15.58	
Calcium Nitrate	75	7.64	7.55	10.17	10.56	—	—	11.83	12.43	14.20	15.10
	150	7.46		10.96		13.00		13.03		15.99	
Urea	75	7.58	7.83	9.92	10.39	11.50	12.00	11.80	12.03	13.44	14.18
	150	8.08		10.85		12.51		12.26		14.93	
S. D. required				1.10	0.78	0.98	0.69	1.05	0.74	1.32	0.93

Again in the third year (1954) sulphate of ammonia produced the highest yield and this was significantly higher than urea. The yield produced by oilcake only just missed significance over urea. Comparison with calcium nitrate is not possible as the 75 lbs. of this nitrogen dressing was not applied due to the shortage of this manure and these plots were treated as Check.

In the fourth year (1955) nitrogen in the form of oilcake produced the highest yields and this was significantly higher than calcium nitrate and urea. The yield produced by sulphate of ammonia was only significantly higher than that produced by urea. The heavier dressing produced significantly higher yields over the smaller dressing in all manures except urea.

In the fifth year (1956) oilcake again produced the highest yield and this was significantly higher than sulphate of ammonia and urea, and despite the omission of the treatment in 1953, the yield produced by calcium nitrate only just missed significance over urea. The heavier dressing produced significantly higher yields over the lighter dressing in all other manures.

In 1956, 150 lbs. of nitrogen in the form of oilcake under full light gave the highest yield which was significantly higher than all other forms of manure at the rate of 150 lbs. of nitrogen under full light.

150 lbs. nitrogen as oilcake and sulphate of ammonia produced significantly higher yields than 75 lbs. of nitrogen both under 100% and 50% (medium) light. As in 1955 higher yields were obtained with 75 lbs. nitrogen with all forms of manure under the lighter shade, but these were not significantly higher than the yields produced by 75 lbs. nitrogen under the other two light intensities.

As in 1955, 150 lbs. nitrogen as sulphate of ammonia and oilcake produced the highest yields under 100% light and lowest under the heaviest shade whereas with calcium nitrate and urea the indications were that the yields were highest under 50% light.

Table 15: Yields in mds. made tea per acre.

Manure		Oilcake		S. O. A.		Calcium Nitrate		Urea	
Dressing		75	150	75	150	75	150	75	150
L I G H T	100%	13.62	18.85	14.28	16.89	13.46	15.75	13.22	15.09
	50%	15.34	17.22	14.44	15.26	15.01	16.32	13.79	15.18
	40%	14.28	15.58	13.38	14.60	14.12	15.91	13.30	14.52

Significant difference required at 5% level = 2.28

It can be seen from the above table that the heaviest shade density has significantly reduced the yield with the higher level of manure in the cases of oilcake and sulphate of ammonia than the corresponding yields under full sun.

Dry tea and liquor characters.— The tea in this areas was manufactured on a large scale from 20th June, 1956 to 10th October, 1956 and in all there were seven manufactures, and the teas were tasted and reported on by two tasters,—(1) Mr. Gilchrist of the Jorehaut Tea Co., Ltd., (2) a panel of tasters in Calcutta. The main object of this experiment was to study the effects of the three different light intensities *i.e.* 40%, 50% and 100% of full light on the cup characters of the made teas.

The following attributes were put to statistical analysis :—

Quantity of tip, Colour of tip, Dry leaf, Infused leaf, Colour of liquor, Strength of liquor, Quality, Briskness and Valuation.

The following showed significant differences which are described briefly below:—

- (i) *Infused leaf.*—The effect of light intensity is significant. 100% light is significantly better than 40% and 50% and there is no difference between 40% and 50%.
- (ii) *Colour of Liquor.*—The effect of light intensity is significant. Both 40% and 50% lights are significantly better than 100% light, and there is no difference between 40% and 50% light.

In the other attributes namely Quantity of Tip, Colour of Tip, Dry Leaf, Strength of Liquor, Quality, Briskness and Valuation, there is no significant difference in the different light intensities.

The differences shown by the light intensities in the infused leaf and colour of liquor have not produced any significant difference in the valuation. There is thus no difference in the valuation under artificial shade giving 40% and 50% light over no shade under the conditions obtaining in this area of tea.

Mechanical Harvesting.—Expt. B. 6.2 :

Trial of the mechanical harvester was continued during 1956 in an area of tea planted in 1935 at 4 ft. $\times$ 4 ft. square spacing. The mechanical harvester was compared with two other methods of hand plucking *i.e.* hand plucking on a weekly round and hand plucking on a somewhat longer round but plucked on the same days as with the mechanical harvester. As in 1955, no definite plucking round was fixed for the mechanical harvester, but as far as possible it was done in a weekly round.

The plots are long plots of a single row of tea containing 100 bushes per plot and replicated 8 times.

As various modifications etc. had to be made to the machine from time to time and particularly from mid September, no proper crop records could be kept after 14th September, 1956 and on two other occasions prior to that date; these particular crop records were excluded from the analysis to eliminate any bias.

The yield figures did not show any significant difference between the three treatments as will be seen from the following table :—

Table 16: Yield in mds. made tea per acre.

(Not adjusted for unmanufacturable leaf.)

Hand plucking in a weekly round.	Mechanical harvesting as far as practicable on a weekly round.	Hand plucking on the same day as machine.
10.33	9.76	10.24

Difference required for significance at 5% level = 0.88 mds.

Shoot counts were made at regular intervals to observe the types of shoots that were being gathered by the different methods of plucking and the average figures for the year are shown in the following table as percent weight of different types of leaf : —

Table 17: (Percent of total fresh leaf plucked.)

Type of shoots Treat- ments	2 & a bud	1 & a bud	Double Banjhi	Single Banjhi	Damaged but manu- facturable leaf	Total % of fine leaf	4 & a bud	3 & a bud	Triple Banjhi	Hard stalk and old leaf not suitable for manufacture	Old stalk with bud i. e. cut below previous level
Weekly hand plucking	51.5	10.6	9.1	3.1	4.3	78.5	0.5	17.5	2.7	...	...
Mechanical harvesting	25.6	6.4	6.2	2.0	18.9	59.1	3.6	17.5	3.2	12.3	3.0
Hand plucking on same day as mechanical harvesting	56.8	7.1	7.0	2.6	3.1	76.6	1.0	18.2	3.0	...	...

Although there has not been any significant difference in the yield from the mechanically harvested leaf, the actual yields of manufacturable and fine leaf are low, there being a total of 15.3% unmanufacturable leaf.

With further improvements to the machine it should be possible to reduce the percentage of unmanufacturable leaf. It is also proposed to introduce a regular rise in plucking height in 1957, with a view to improvement in both the yield and type of shoots plucked.

Times required to pluck an acre of tea under the three different treatments were recorded and the average times required are given in the table below:—

Table 18 : (Man hours in case of machine.)

Method of plucking	Woman hours (man hours in case of machine) required per acre of tea planted 4' x 4' square.	No. of bushes plucked per hour per woman or machine.
Weekly hand plucking ...	45 hrs. 22 mins.	60
Mechanical harvesting ...	5 hrs. 18 mins.	517
Hand plucking on the same day as mechanical harvesting ...	47 hrs. 36 mins.	57

At the end of the 1956 plucking season, the plots were re-arranged for the introduction of a new mechanical harvesting treatment in 1957 and all plots due for mechanical harvesting in 1957, were pruned mechanically.

Annual December Vs. Biennial October Prune—Expt. B. 5A.

The results of this experiment were discussed in the Annual Report, 1955. At the end of 1956, this area was medium pruned. It then became apparent that many of the bushes had suffered from sun-scorch damage in the past and

this appeared to be associated with the treatments. It was, therefore, decided to count the number of lesions caused by sun-scorch and also to categorise the bushes into the following categories of damage by visual observation, taking into account the severity of the wounds and the number of lesions :—

<i>Serial No.</i>	<i>Kind of damage.</i>	<i>Degree of Severity.</i>
1 ...	No damage	S_0
2 ...	Light damage	S_1
3 ...	Medium heavy damage	S_2
4 ...	Severe damage	S_3

Number of Lesions.—The following table gives the total number of lesions in the bushes:—

Table 19.

<i>Time of Prune</i>	<i>No. of lesions</i>
Annual prune in December ...	472
Biennial prune in October ...	1131
Significant difference required ($P = .001$) ...	281.5

Severity of Damage.—The following table gives the total number of bushes in the different categories of damage:—

Table 20.

<i>Severity of damage</i>		S_0	S_1	S_2	S_3	Total
<i>Pruning treatment</i>						
Annual prune in December ...		399.73	255.65	148.52	74.53	878.43
Biennial prune in October ...		263.68	272.12	231.49	177.77	946.06

Difference required for significance ($P = .001$) of the pruning treatments:—20.81.

Difference required for significance ($P = .001$) of the severity of the damage:—63.09.

The above figures show that when bushes are biennially pruned in October, they suffer severely from sun-scorch damage. Some of the branches of the damaged bushes are dying or have already died and in many cases whole bushes are dying.

The main cause of the sun-scorch being severe in the October pruned plots is likely to be the stronger sun in October, and the time of pruning rather than the frequency is the cause.

Treatment of Medium Pruned Tea.—Expt. B. 9,2 :

It is known that medium pruning gives a severe shock to the tea bushes and as a result many bushes are often set back for a long time and some even die. It has already been proved that the more severe the prune is, the more severe is the shock to the bush and bigger is the loss in crop.

Resting	Manure	Time of Manuring	Time of Medium Pruning	Medium Prune	ment No.
Tea not rested. Was tipped and plucked at 38" in the season after the medium prune	Nitrogen @ 80 lbs. per acre	Manure applied one month before medium pruning	in April 1953	18"	1a
				20 $\frac{1}{2}$ "	1b
				18"	2a
				20 $\frac{1}{2}$ "	2b
		Manure applied after medium pruning when 3 leaves had formed	in April 1953	18"	3a
				20 $\frac{1}{2}$ "	3b
				18"	4a
				20 $\frac{1}{2}$ "	4b
	N. P. K. in the proportion of 1.2.2. applying 80 lbs. N per acre	Manure applied one month before medium pruning	in April 1953	18"	5a
				20 $\frac{1}{2}$ "	5b
				18"	6a
				20 $\frac{1}{2}$ "	6b
		Manure applied after medium pruning when 3 leaves had formed	in April 1953	18"	7a
				20 $\frac{1}{2}$ "	7b
				18"	8a
				20 $\frac{1}{2}$ "	8b

9a	{	Manure applied one month before medium pruning	{	in April 1953	{	18"	9a
9b 10a	{		{	in October 1952	{	20½" 18"	9b 10a
10b 11a	{	Manure applied after medium pruning when 3 leaves had formed	{	in April 1953	{	20½" 18"	10b 11a
11b 12a	{		{	in October 1952	{	20½" 18"	11b 12a
12b 13a	{	Manure applied one month before medium pruning	{	in April 1953	{	20½" 18"	12b 13a
13b 14a	{		{	in October 1952	{	20½" 18"	13b 14a
14b 15a	{	Manure applied after medium pruning when 3 leaves had formed	{	in April 1953	{	20½" 18"	14b 15a
15b 16a	{		{	in October 1952	{	20½" 18"	15b 16a
16b	{		{		{	20½"	16b
17	{	Not medium pruned. Top pruned in December 1952 and usual manuring with 80 lbs. N. only	{		{	...	17
18	{	Medium pruned in November 1952 at 24" and not manured in the year after medium prune	{		{	Rested for one year after medium prune Not rested, but plucked at 36"	18
19	{		{		{		19

Tea rested
by leaving
unplucked
for one year
after the
medium
prune.

Check

Table 21: Yield in mds. made tea per acre.

Treatment No.		1953	1954	Cumulative yield 1953-54	1955	Cumulative yield 1953-55	1956	Cumulative yield 1953-56
OT	1 a	3.44	6.21	9.65	10.26	19.91	8.59	28.50
	1 b	3.76	6.16	9.92	10.66	20.58	9.24	29.82
R	2 a	5.48	8.77	14.25	9.50	23.75	7.72	31.47
	2 b	6.34	9.73	16.07	10.61	26.68	8.86	35.54
E	3 a	3.09	7.06	10.15	11.25	21.40	9.97	31.37
	3 b	3.62	6.78	10.40	10.33	20.73	9.67	30.40
T	4 a	5.78	10.39	16.17	10.05	26.22	9.72	35.94
	4 b	5.68	9.68	15.36	9.37	24.73	8.81	33.54
E	5 a	4.04	6.45	10.49	10.50	20.99	9.42	30.41
	5 b	4.54	7.05	11.69	11.97	23.66	10.60	34.16
D	6 a	5.95	10.92	16.87	10.99	27.86	9.33	37.19
	6 b	6.77	10.42	17.19	9.61	26.80	8.56	35.36
	7 a	4.12	10.14	14.26	11.30	25.56	9.80	35.36
	7 b	3.90	8.15	12.05	11.91	23.96	10.25	34.21
	8 a	6.63	10.88	17.51	10.93	28.44	9.42	37.86
	8 b	6.78	11.29	18.07	11.40	29.47	10.17	39.64
	9 a	2.20	5.80	8.00	8.40	16.40	8.78	25.18
	9 b	2.20	5.67	7.87	9.50	17.37	10.01	27.38
R	10 a		8.47	8.47	9.19	17.66	9.24	26.90
	10 b		8.50	8.50	9.29	17.79	9.08	26.87
E	11 a	1.62	5.63	7.25	9.46	16.71	9.00	25.71
	11 b	1.47	5.10	6.67	8.58	15.15	8.51	23.66
S	12 a		9.36	9.36	9.00	18.36	9.53	27.89
	12 b		9.38	9.38	9.67	19.05	8.77	27.82
T	13 a	2.54	5.52	8.06	10.70	18.76	10.13	28.89
	13 b	2.02	5.48	7.50	9.33	16.83	8.84	25.67
E	14 a		9.47	9.47	8.98	18.45	8.86	27.31
	14 b		9.22	9.22	9.10	18.32	8.79	27.11
D	15 a	1.88	6.47	8.35	10.33	18.68	9.76	28.44
	15 b	1.97	6.50	8.47	11.20	19.67	10.75	30.42
	16 a		9.90	9.90	9.00	18.90	8.84	27.74
	16 b		10.65	10.65	10.10	20.75	9.76	30.51
	17	5.79	8.23	14.02	8.29	22.31	7.56	29.87
	18		8.72	8.72	9.65	18.37	9.45	27.82
	19	5.34	8.18	13.52	10.23	23.75	8.27	32.02
S. D. required for comparisons between Checks and the other treatments.			1.70					

This experiment was primarily designed therefore to ascertain whether time of manuring, actual time of medium pruning, or other cultural operations can assist the recovery of bushes from medium prune, and increase yield over a number of years.

The plots were medium pruned in October 1952 and April 1953, depending upon the treatments. The two check treatments 18 and 19 were, however, medium pruned at 34" in November 1952.

Crop records have been kept in each year between 1953 and 1956. The rested plots were rested between October 1952 and October 1953, and from April 1953 to April 1954 as the case may be and hence only in 1954 were all the plots plucked. The crop records of 1954 have been statistically analysed and their correlation with the cumulative yields up to 1956 has been worked out. This correlation has been found to be highly significant, indicating that the trend of the cumulative yield up to 1956 under the different pruning systems have remained the same as in 1954. Comparisons made below of the different treatments have been based on the results of 1954 yields.

When Treatment No. 17 (i.e. the tea that was not medium pruned at all) is compared with the other treatments, all the treatments medium pruned in October gave higher yield whether the tea was rested or not.

Medium pruning in April is worse than medium pruning in October whether the tea is rested or not and when rested, medium pruning in April is significantly worse than this check Treatment No. 17.

When Treatment No. 18 (tea medium pruned in November 1952 at 24" and not manured in the season after the medium pruning, but rested for one year) is compared with other rested treatments, it is seen that tea medium pruned in April, whether at 18" and 20½" produced significantly lower yields ($P = .05$) whereas tea medium pruned in October at the same heights as above produced similar yields as Treatment No. 18, only exception being the tea that was medium pruned in October at 20½" and manured with a N.P.K. mixture after the prune, which has given a higher yield.

Treatment No. 19 (tea medium pruned in November 1952 at 24" and neither manured nor rested for one year) at the time of starting the experiment, was more or less the normal recommended method. During the days of shortage of manures, it was suggested that medium pruned tea need not be manured in the year of the prune, as a measure of economy.

When this treatment (No. 19) is compared with the different non-rested treatments, it is seen that tea medium pruned in October gave significantly higher yields except in the cases where nitrogen only was applied before the prune and where nitrogen was applied after but pruned at 20½".

Taking all the treatments into consideration, the following main effects only have produced significant results:—

- (a) The tea that was rested for a year after the medium prune produced significantly lower yields ($P \times .001$) in 1954 and the same trend has been maintained in the total yield up to 1956.
- (b) The tea pruned in April produced significantly lower yields ($P < .001$) in 1954, than the tea pruned in October, and the same trend has been maintained in the total yield up to 1956.
- (c) The indications are that tea that is medium pruned at 24" in November and not manured at all in the year following, does not yield as much as when the tea is medium pruned in October and is manured with nitrogen alone.
- (d) Tea manured with an N.P.K. mixture in the proportion of 1.2.2 applied at 80 lbs. of nitrogen per acre, produces significantly higher yield ($P = .01$) than tea manured with nitrogen only at 80 lbs. per acre.
- (e) Manuring medium pruned tea after the prune when three leaves are formed is significantly better than manuring one month before the medium prune.

Manuring of Bamboo.—Expt. B. 9A :

An NPK manurial trial is now being carried out at Borbhetta on young bamboo plants planted early in 1954. The trial was started in July 1955 and the last two years' results are now available. There are four treatments and five replications *i.e.* 20 plots in all. Each plot is represented by a bamboo clump. As far as possible clumps with uniform height and growth were selected for the trial.

The following treatments were applied in July, 1955 after taking preliminary observations on height and number of tillers of each clump.

Table 22.

Treatment	Ammonium sulphate per clump (in lb.)	Super-phosphate per clump (in lb.)	Potassium sulphate per clump (in lb.)	TOTAL (in lb.)	Ratio of N.P.K.		
					N	P	K
A	1 $\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	2.0	4	1	2 $\frac{1}{2}$
B	1 $\frac{1}{8}$	—	$\frac{1}{8}$	1 $\frac{2}{8}$	4	0	2 $\frac{1}{2}$
C	1 $\frac{1}{8}$	$\frac{1}{8}$	—	1 $\frac{2}{8}$	4	1	0
D (Check)	—	—	—	—	—	—	—

The mixture was applied in a circle of 10 ft. diameter.

Observations.— Observations on height and number of tillers of each clump were taken. First observations were taken in February 1956 and second in November 1956. In the second year, similar manuring was done in early February *i.e.* just after the first observation.

Results.— The results of covariance analysis of height and number of tillers are given below:—

Table 23.

Treatment	Mean adjusted height in feet		Mean adjusted no. of tiller	
	1955	1956	1955	1956
A	17.38	24.69	3.6	7.2
B	17.55	29.57	3.2	8.0
C	20.37	31.38	4.6	9.8
D	15.31	20.86	2.8	5.2
S.D. at 5%	3.26	5.33	Not significant	2.78
Order of effect of treatment	C.B.A.D.	C.B.A.D.	C.A.B.D.	C.B.A.D.

Table 24 : % increase in height and number of tillers due to N.P.K. manuring over no manure.

Treatment	% increase in height		% increase in no. of tillers	
	1955	1956	1955	1956
A	13.5	18.3	28.6	38.4
B	14.6	41.8	14.3	54.0
C	33.0	50.4	64.3	88.4

The above two tables show that Treatment C (NP) gave the best result in the last two years—in the second year its effects were even more pronounced. In the second year this treatment significantly increased the height over Treatment A (NPK) and D (no manure).

In the case of number of tillers per clump, Treatment C (NP) just failed to show any significant result in the first year but the same trend as for heights was noticed. In the second year, however, Treatment C (NP) produced significantly higher number of tillers than Treatment D.

From the results stated above it is seen that a complete mixture of NPK actually depressed growth as both NP and NK showed better results, particularly the former.

Hence, it may be concluded that under the conditions of the trial, a mixture of ammonium sulphate and superphosphate in the ratio of 4:1 (or NP ratio of 4:1) increases the growth and development of young bamboos. Inclusion of potassium sulphate with the above in the ratio of 4:1:1 (or NPK ratio of 4:1:2 $\frac{1}{2}$) adversely affects the development.

ADVISORY

Correspondence.— 222 letters were written by this branch in answer to queries on technical matters.

Touring.— The Senior Agriculturist visited 52 gardens in the districts including the Dooars, Terai, Darjeeling and Cachar. The Assistant Agriculturist visited 5 gardens in Darjeeling.

Meetings.— The Senior Agriculturist attended and addressed the Annual General Meeting of the Darjeeling Branch, Indian Tea Association, on 3rd March 1956, and the Annual General Meeting of the Indian Tea Planters' Association, Jalpaiguri on the 14th April 1956.

Lectures.— The Senior Agriculturist delivered one lecture to the planters in the Darjeeling Planters' Club on 22nd September 1956 and two lectures on "Pruning" and "Spacing of Tea" in the 13th Annual Conference in November 1956.

Courses.— The Senior Agriculturist ran one three-week practical course on Vegetative Propagation in April/May 1956 and two Special Courses on the same subject in the last week of October 1956.

Publications.— The following Encyclopaedia Serials were published :—

Serial No. 10/2 — jointly with the Senior Advisory Officer, Assam.

Serial No. 46/1 — jointly with the Senior Advisory Officer, Assam.

Serial No. 111 — jointly with the Senior Advisory Officer, Assam.

Serial No. 80/1 — jointly with the Assistant Agriculturist.

BORBHETTA EXPERIMENTAL ESTATE REPORT

Labour.— The average daily attendance during the year was :—

Tocklai	...	...	21.34
Borbhetta	...	...	370.75

In April there was labour agitation for the payment of bonus, in accordance with the Delhi Agreement for Tea Plantations Workers in North East India. They were informed that as bonus is payable on profits only and this being a non-profit making concern, it was not possible for them to be paid any bonus. Whilst negotiations were still in progress, the Borbhetta labour went on strike from the 2nd May to 4th May 1956. As a result of further negotiations later, an award was made of a Special Compensatory Allowance. Labour relations at the end of the year were satisfactory.

Crop Yield.— The total yield of green leaf during the year compared with that of 1955 was as follows :—

1955	...	...	2,43,788 lbs.
1956	...	...	2,54,590 lbs.

Of the 1956 crop, 2,36,876 lbs. were sold to Messrs. Jorehaut Tea Co., Ltd. General plucking was stopped from the 16th November 1956.

Building.— Owing to shortage of cement much of the building work remained uncompleted. However, the following have

been built:—Six pucca labour quarters. The Senior Field Assistant's quarter. A pucca quarter for the midwife.

Lands— $15\frac{2}{3}$ acres of land were purchased at and near Borbhetta during 1956. This brings the total of new land purchased since 1955 to $23\frac{2}{3}$ acres. The land position remains acute and efforts are being made to purchase more. Land has already been cleared for tea to be planted up for three new experiments and nurseries.

PLANT PATHOLOGY BRANCH REPORT ENTOMOLOGICAL SECTION

G. M. DAS—Senior Entomologist.

STAFF

Mr. R. N. Ganguli, M.Sc., joined the Branch as Senior Assistant in place of Mr. D. K. Dutt who resigned, Mr. U. C. Bania, B.Sc., in place of Mr. D. K. Mahanta, B.Com., Messrs. N. G. Goswami, and S. C. Das, M.Sc., as Technical Assistants.

RESEARCH AND EXPERIMENT

Looper caterpillar :

Reports of heavy outbreaks of Looper caterpillar were received from the North Bank, where a number of gardens were severely affected by the pest. Due to incessant rains, little spraying could be done for its control and in most cases hand-collection of caterpillars had to be resorted to. DDT was however applied to restricted areas, but it failed to give adequate control of the pest as it was washed away by rains.

The loss incurred by the ravages of this pest was considered to be heavy. A few gardens had some areas more or less completely defoliated and special manurial treatments had to be made for recovery of the plants.

In order to find a more effective insecticide which would give immediate kill of full-grown Looper caterpillar, exploratory trials were carried out at Tocklai and the results indicated that Endrin might be an answer to this problem. The earliest opportunity was therefore availed of to carry out field trials with Endrin, along with Dieldrex and DDT for comparison. These were carried out at Dufflaghur and Sapoi Tea Estates. Treatments were applied at the later part of the second brood when the caterpillars were almost full-grown.

Spraying was done in Dufflaghur by means of a Holder Harriden Knapsack Sprayer fitted with low volume nozzle, using about 100 gallons of spray per acre. It was drizzling during application, the total rainfall recorded within the 24 hrs. after treatment being 0.5".

Table 1 : Dufflaghur Trial.

Treatments	Percent kill within 24 hrs. (Mean of 4 replications.)
Endrin 19.5% E.C. at 1 in 1000 parts water	87.8
Endrin 19.5% E. C. at 1 in 1,500 parts water	31.9
Dioldrex 18 E. C. at 1 in 1,000 parts water	19.3
Dioldrex 18 E. C. at 1 in 1,500 parts water	10.6
DDT 50% W. P. at 1 lb. in 20 gallons water	5.7
Significant difference at 5% level	16.95

Table 2 : Sapoi Trial.

Treatments	Percent kill within 24 hrs. (Mean of 4 replications)
Endrin 19.5% E. C. at 1 in 1,000 parts water ...	96.2
Endrin 19.5% E. C. at 1 in 1,500 parts water ...	61.7
Dioldrex 18 E. C. at 1 in 1,000 parts water ..	50.4
Dioldrex 18 E. C. at 1 in 1,500 parts water ..	7.0
DDT 50% W. P. at 1 lb. in 20 gallons water ...	1.9
Significant difference at 5% level ...	11.25

Application was made in Sapoi by means of an ordinary Knapsack Sprayer fitted with high volume nozzle, and using about 150 gallons of spray per acre. It rained heavily about 4 hours after application, the total rainfall within the 24 hrs. being 2.5".

In both trials, Endrin 19.5% E.C. (emulsifiable concentrate) at 1 in 1000 parts water proved to be significantly superior to all other treatments in controlling Looper caterpillar, and 85—95% kill of almost full-grown Loopers was obtained within 24 hrs. after treatment. At 1 in 1500 parts, it gave a moderate kill of Loopers. Dioldrex at 1 in 1000 parts water gave better control than DDT in one trial, but in the other it did not prove to be superior to DDT.

It appears from the results of the trials carried out at Dufflaghur and Sapoi T.Es., that even slight rains at the time of application or shortly after, may not appreciably reduce the efficacy of Endrin when applied at a concentration of 1 in 1000 parts water.

A trial was conducted at Behora T.E. where application was made either by means of high volume or low volume sprayers using 60, 100 or 150 gallons of spray per acre at different concentrations in order to reduce Endrin residues likely to be

carried over to made tea. DDT and Toxaphene were also included for comparison.

Table 3 : Behora Trial

Treatments.	Percent kill within 24 hrs. (mean of 3 replications).	Percent kill within 48 hrs. (mean of 3 replications).
Endrin 19.5% E. C. ($\frac{1}{2}$ pint) at 1 in 1000 parts water, using 60 gallons per acre (low volume)	49.8	68.7
Endrin 19.5% E. C. ($\frac{4}{5}$ pint) at 1 in 1000 parts water using 100 gallons per acre (low volume)	79.8	88.4
Endrin 19.5% E. C. ($1\frac{1}{4}$ pint) at 1 in 1000 parts water using 150 gallons per acre (High volume)	88.2	94.7
Endrin 19.5% E. C. ($\frac{1}{2}$ pint) at 1 in 2400 parts water using 150 gallons per acre (High volume)	64.4	75.9
DDT 50% W. P. ($7\frac{1}{2}$ lbs.) at 1 lb. in 20 gallons water using 150 gallons per acre (High volume)	23.8	44.9
Toxaphene 50% E. C. (6 pints) at 1 in 200 parts water using 150 gallons per acre (High volume)	60.9	71.5
Check (Untreated)	0.0	0.0
Significant difference at 5% level ...	20.73	15.4

From the above results it is evident that Endrin ($1\frac{1}{4}$ pint) at 1 in 1000 parts water using 150 gallons of spray per acre gives the most effective control of Looper. With 100 gallons of spray ($\frac{4}{5}$ pint E.C.) similar control can be obtained. While 60 gallons of spray ($\frac{1}{2}$ pint E.C.) applied by means of a low volume sprayer gave fairly satisfactory control, the same quantity of Endrin ($\frac{1}{2}$ pint E.C. per acre) at higher dilution of 1 in 2400 parts water applied by means of high volume sprayer gave similar results.

It therefore appears that $\frac{1}{2}$ pint of Endrin 19.5% E.C. in 150 gallons of water (1 in 2400 parts) per acre applied by means

of a high volume sprayer leaves less residue on the leaf than what can be expected from any other treatment of Endrin.

Endrin is a highly toxic insecticide and its residue tolerance on raw agricultural commodity is very low. The residues of Endrin that are likely to be carried over to made tea are being evaluated by manufacturers and until this information is available and relevant studies in the use of Endrin are made, it should on no account be used on tea in plucking. Toxaphene 50% E.C. also gave satisfactory control of Looper, but the dosage rate is so high that it may not be economical to use it for control of Looper. However, the tolerance level of Toxaphene for raw agricultural commodities is high and the question of its use on tea is being investigated.

Termite control trials :

Further estimate of the incidence of termites in the treated plots with Aldrin and Dieldrin in 1955 at Silcoorie and Borokai Tea Estates was made this year with the following results:

Table 4 : Silcoorie Trial (1955)—Dhuramkhal T.E.

Date of treatment— April, 1955.	Date of observation— December, 1956.
Treatments.	Average earth-runs per bush (mean of 5 replications).
Aldrin 40% W. P. @ 2 lbs. actual per acre (1 lb. in 50 gallons of water) ...	0.01
Aldrex 24 E. C. @ 2 lbs. actual per acre ...	0.04
Dieldrin 50% W. P. @ 2 lbs. actual per acre...	0.02
Dieldrex 18 E. C. @ 2 lbs. actual per acre ..	0.00
Aldrin 5% dust @ 80 lbs. per acre (4 lbs. actual) mixed with S. O. A. ...	0.00
Aldrin 5% dust @ 80 lbs. per acre (4 lbs. actual) mixed with Oilcake ...	0.00
Dieldrin 1% dust @ 400 lbs. per acre (4 lbs. actual) mixed with S. O. A. ...	0.00
Dieldrin 1% dust @ 400 lbs. per acre (4 lbs. actual) mixed with Oilcake ...	0.00
Check (Untreated) ...	0.22
Significant difference at 5% level ...	0.07

It is evident that all treatments are significantly superior to check in maintaining the reduction in the incidence of termites

in the second year after application. There is no difference amongst the treatments of Aldrin and Dieldrin applied either alone @ 2 lbs. active material as soil treatment or 4 lbs. active material mixed with fertilisers as broadcast.

Table 5 : Borokai Trial (1956)

Date of treatment—April, 1955.				Date of observation— December, 1956.
Treatments				Average earth-runs per bush (mean of 4 replications)
Aldrex 24 E. C. @ 4/5 gallons per acre (2 lbs. actual)	...	...	...	0.84
Aldrin 5% dust @ 80 lbs. per acre (4 lbs. actual) mixed with S. O. A.	...	...	...	1.11
Aldrin 5% dust @ 80 lbs per acre (4 lbs. actual) mixed with Oilcake	...	...	...	0.42
Dieldrin 1% dust @ 400 lbs. per acre (4 lbs. actual) mixed with S. O. A.	...	...	...	0.55
Dieldrin 1% dust @ 400 lbs. per acre mixed with Oilcake	...	...	...	0.54
Check (Untreated)	...	...	...	1.03
Significant difference at 5% level	...	...	...	0.48

Both Aldrin and Dieldrin @ 4lbs. active material per acre applied broadcast mixed with oilcake and also Dieldrin with Sulphate of Ammonia were significantly superior in checking the termite incidence in the second year after treatment, whereas Aldrex @ 2 lbs. active material applied as a spray was in no way better than the check. Aldrin @ 2 lbs. active material applied broadcast mixed with Sulphate of Ammonia however recorded higher incidence of termites than in the check. It may be mentioned that the termite incidence was higher in this treatment even in the year of application (*vide* Annual Report 1955, p. 89), for which no reason can be assigned.

Helopeltis Control :

With a view to finding out comparative efficacy of DDT, Dieldrin and Malathion in controlling *Helopeltis*, a trial was carried out at Pallorbund Tea Estate (Narainpur), Cachar.

Table 6.—Pallorbund Trial

Treatments.	Percent new shoots affected.	
	After 15 days.	After 1 month.
DDT 50% W. P. at 1 lb. in 50 gallons water ...	42.42	40.4
Dieldrin 50% W. P. at 1 lb. in 50 gallons water	45.08	43.7
Dieldrex 18 E. C. at 1 in 1000 parts water ...	38.40	39.2
Malathion 50% E. C. at 1 in 800 parts water ...	48.94	41.0
Check (Untreated)	72.22	71.6
Significant difference at 5% level ...	8.65	10.08

The results indicate that DDT, Dieldrin and Malathion are all equally effective, there being no significant difference between these treatments. The question of using Dieldrin instead of DDT for control of *Helopeltis* does not therefore arise, particularly when various factors are involved in its use. Malathion is however equally as effective as DDT, besides having acaricidal properties. Though it is an organophosphorus compound and is likely to be absorbed by the plant tissues, its toxicity to mammals is of a very low order, acute oral approx. LD. 50 mg/kg* being 1845 for rats whereas for DDT it is 250. The possibility of using Malathion for control of various pests is being investigated.

Bunch Caterpillar :

Hand collection is the easiest method of control of gregarious insects such as Bunch Caterpillar, which remains clustered on stems during the day time, but in a case where the attack is widespread, it may be necessary to resort to chemical control.

*The Lethal Dose of Malathion which when taken by mouth causes 50% mortality of rats is 1845 milligrammes per kilogramme bodyweight whereas for DDT, it is 250 milligrammes.

A trial was therefore carried out at Borbhetta with Lindane, Dieldrex, Aldrex, Malathion, DDT and Endrin for its control. As the attack was confined to a small area, the trial was a simple one, not statistically designed.

Table 7 : Bunch Caterpillar Control

Treatments	Total caterpillars	Within 24 hrs.		Within 48 hrs.	
		Number killed	Percent killed	Number killed	Percent killed
Lindane 20% E. C. at 1 in 1000 parts water ...	96	84	87.5	96	100.0
Dieldrex 18 E. C. at 1 in 1000 parts water ...	88	36	40.9	75	85.2
Aldrex 24 E. C. at 1 in 1000 parts water ...	90	16	17.8	44	48.9
Endrin 19.5% E. C. at 1 in 1000 parts water ...	92	84	95.7	92	100.0
Malathion 50% E. C. at 1 in 1000 parts water ...	91	13	14.3	36	39.6
DDT paste at 1 in 500 parts water ...	115	75	65.2	105	91.3
DDT 50% W.P. at 1 lb. in 50 gallons water ...	98	57	58.2	86	87.7
Check (Untreated) ...	83	0	0.0	0	0.0

Lindane and Endrin were found to be most effective against Bunch caterpillar. Dieldrin and DDT (W.P. and Paste) also proved to be highly effective whereas Aldrex and Malathion gave a moderate kill. Further trials are contemplated for confirmation.

Cricket Control Trial at Bagdhora, 1956 :

A trial was carried out with Aldrin and Dieldrin applied as dusts to nursery soil as pre-sowing treatments against crickets at Bagdhora area of Cinnamara T.E. Observations were made

on the incidence of Crickets as indicated by fresh holes at fortnightly intervals with the following results :—

Table 8 : Cricket Control

Treatments	Number of holes found throughout the year (Mean of 6 replications)
Aldrin 5% dust @ 2 lbs. actual per acre ...	1.5
Dieldrin 1% dust @ 2 lbs actual per acre ...	1.3
Check (Untreated) ...	8.2
Significant difference at 5% level ...	1.60

Aldrin and Dieldrin were significantly superior to check, both being equally effective in checking the incidence of Crickets.

Ants associated with tea Coccids :

The relationship between ants and some honeydew excreting Coccids occurring on tea in the plains has been studied in some detail. The populations of the Coccids, *Eriochiton theae* and *Coccus hesperidum* on seed trees are considerably reduced in the absence of the attendant red ant, *Oecophylla smaragdina*, whereas *Saissetia formicarii* completely disappears in the absence of the ants *Crematogaster dohrni* and *Crematogaster* sp. which imprison it in their nests. Various factors are involved in the reduction of the population of Coccids or their complete disappearance in the absence of attendant ants, the most important ones being the increased activities of their natural enemies, particularly predators, and accumulation of honeydew and subsequent sooty mould growth.

Studies have been made in the following lines :—

1. Activities of predators and parasites in the presence or absence of attendant ants.
2. Whether ants protect Coccids from their natural enemies.
3. Relative populations of ants in the nests, and of Coccids enclosed therein.

4. Whether ants are largely dependant on Coccids for their food or a large proportion of their food come from other sources.
5. Dissemination of Coccids by ants.

All observational data are being summarised and the results will be presented in a paper.

Root borer (*Sternocera aurosignata*) :

Trials were carried out at Julia and Pertabghar Tea Estates in March, 1955, with different formulations of Aldrin and Dieldrin applied at the rate of 2 lbs. actual per acre as pre-sowing treatments to nursery soil against the borer attacking *Albizzia odoratissima* and *A. procera* plants. An estimation of damage was made in March this year but none of the treatments proved to be effective in checking the pest.

Orange mite (*Phytoptipalpus* sp.) :

A simple trial was carried out with Ekatina, a systemic insecticide based on Thiometon for control of orange mite attacking *Albizzia procera* shade tree. The treatments were as follows :—

1. Soil around the collar sprayed with Ekatina (1 : 1000)
@ $\frac{1}{2}$ gallon spray fluid per tree.
2. Soil around the collar sprayed with Ekatina (1 : 1000)
@ 1 gallon spray fluid per tree.
3. Soil around the collar sprayed with Ekatina (1 : 1000)
@ $1\frac{1}{2}$ gallon spray fluid per tree.
4. Trunk of the tree sprayed with Ekatina (1 : 1000)
@ 1 gallon spray fluid per tree.
5. Check (Untreated).

Observations were made at monthly intervals for three months and none of the treatments was found to be effective against this mite.

Green Caterpillar (*Rhesala moestalis*) :

A trial was carried out with Dieldrex, Endrin, DDT and Lindane to study the comparative efficacy of these insecticides in controlling Green caterpillar attacking shade nursery plants at Cinnamara Tea Estate.

Table 9 : Green caterpillar Control.

Treatments	Percent caterpillars killed within 24 hrs.
Dieldrex 18 at 1 in 1000 parts water ..	96.87
Endrin 19.5% E.C. at 1 in 1.00 parts water ...	94.42
DDT 50% W.P. at 1 lb. in 50 gallons water ...	46.93
Lindane 20% M.C at 1 in 1000 parts water ...	96.65
Check (Untreated)	0.0
Significant difference at 5% level	18.63

Dieldrin, Lindane and Endrin gave highly satisfactory control of Green caterpillar, there being no significant difference amongst them, whereas DDT gave a moderate kill within 24 hours after treatment.

Red spider Control :

The following new acaricides were tried out in the laboratory against various stages of Red spider.

- (1) Whiz (with 4% thanite)—Messrs. John Paterson & Co., Ltd.
- (2) HRS 836 (Dibenzyl disulphide)—Messrs. Boots Pure Drug Co., Ltd.
- (3) HRS 2271 (p-Cyanobenzyl p-chlorophenyl sulphide)—Messrs. Boots Pure Drug Co., Ltd.
- (4) HRS 920 (p-nitrobenzyl p-chlorophenyl sulphide) Messrs. Boots Pure Drug Co., Ltd.
- (5) Dimite 25% di (parachlorophenyl) methyl carbinol—Messrs. Bugges Insecticides Ltd.
- (6) R 6199 Hydrogen oxalate of O,O-diethyl S-(B-diethylamine) ethyl phosphorothiolate—Messrs. Imperial Chemical Industries (India) Ltd.

In all laboratory trials, one infested shoot represented one replicate, with 5 replications for each treatment. The size of the sample being often small and variation between the samples being large, the figures have been transformed into angles for statistical analysis. The transformed as well as the actual figures are given in the tables.

Table 10 : Red spider Control—A. Effect on the eggs.
Sub-Table I

Treatments	Percent un- hatched eggs (transformed into angles).	Percent unhatched eggs.
HRS 836 (20% W. P.) at 0.5% concen- tration 	82.50	97.22
HRS 2271 (20% W. P.) at 0.25% concen- tration 	21.17	13.30
HRS 920 (20% W. P.) at 0.25% concen- tration 	19.57	11.60
Check (Untreated) 	7.31	2.76
Significant difference at 5% level ...	8.02	...

HRS 836 was highly effective against Red spider so far as its ovicidal action is concerned, whereas HRS 2271 and HRS 920 were not sufficiently effective though both were superior to check.

Sub-Table II

Treatments	Percent un- hatched eggs (transformed into angles).	Percent unhatched eggs.
HRS 836 (20% W. P.) at 0.5% concen- tration 	71.96	89.98
Dimite at 1 in 800 parts of water ...	30.72	26.28
Check (Untreated) 	8.46	2.98
Significant difference at 5% level ...	8.51	...

In this trial HRS 836 also proved to be highly efficient, as an ovicide, whereas Dimite was slightly effective.

Sub-Table III

Treatments	Percent un-hatched eggs (transformed into angles).	Percent unhatched eggs.
R. 6199 (10 ppm. water)	23·31	17·38
-do- (20 ppm. water)	18·36	11·00
-do- (40 ppm. water)	13·07	5·66
Check (Untreated)	4·71	1·06
Significant difference at 5% level ...	7·70	...

R.6199 did not sufficient kill of Red spider eggs though at all its concentrations it was better than check.

Sub-Table IV

Treatments	Percent un-hatched eggs (transformed into angles)	Percent unhatched eggs.
R. 6199 (10 ppm. water)	23·89	17·72
R. 6199 (40 ppm. water)	22·82	16·30
R. 6199 (20 ppm. water)	15·61	7·88
Check (Untreated)	4·87	1·24
Significant difference at 5% level ...	10·49	...

This confirmed the results of previous trial that R. 6199 was not sufficiently effective as an ovicide.

Table 11 : Red spider Control—B. Residual effect on the freshly hatched larvae.

Sub-Table I

Treatments	Percent larvae killed (transformed into angles).	Percent larvae killed.
Dimite at 1 in 800 parts of water ...	8·01	3·56
HRS 836 (20% W. P.) at 0·5% concentration	5·31	4·00
Check (Untreated)	0·00	0·00
Treatments are not significant.		

The persistent action of Dimite and HRS 836 on the freshly hatched larvae appears to be little.

Sub-Table II

Treatments	Percent larvae killed (transformed into angles).	Percent larvae killed.
R. 6199 (20 ppm. water)	49.78	57.94
R. 6199 (40 ppm. water)	45.85	53.14
R. 6199 (10 ppm. water)	41.51	44.16
Check (Untreated)	0.00	0.00
Significant difference at 5% level ...	18.58	...

R. 6199 in all its concentrations was found to be satisfactory so far its residual effect on the freshly hatched larvae is concerned, there being no difference amongst the three concentrations tried out.

Table 12 : Red spider Control—C. Effect on quiescent forms.

Sub-Table I

Treatments	Percent quiescents killed (transformed into angles.)	Percent quiescents killed.
Dimite at 1 in 800 parts water	85.72	98.60
HRS 836 (20% W. P.) at 0.5% concentration	29.04	28.42
Check (Untreated)	0.00	0.00
Significant difference at 5% level ...	17.52	...

Dimite gave a very high kill of quiescent forms, whereas HRS 836 was only slightly effective.

Sub-Table II

Treatments	Percent quiescents killed (transformed into angles)	Percent quiescents killed.
Dimite at 1 in 800 parts water ...	81.47	94.46
HRS 836 (20% W. P.) at 0.5% concentration ...	25.43	23.36
HRS 2271 (20% W. P.) at 0.25% concentration ...	11.19	9.16
Check (Untreated) ...	0.00	0.00
Significant difference at 5% level ...	15.92	

This confirmed the results of the above trial that Dimite was highly effective against quiescent forms and HRS 836 was only slightly effective.

Table 13 : Red spider Control—D. Effect on the active forms by direct spray.

Sub-Table I

Treatments	Percent active forms killed (transformed into angles)	Percent active forms killed.
Whiz (with 4% Thanite) at 1 in 80 parts water ...	65.73	81.42
HRS 836 (20% W. P.) at 0.5% concentration ...	30.14	25.46
HRS. 2271 (20% W. P.) at 0.25% concentration ...	28.21	24.26
HRS. 920 (20% W.P.) at 0.25 concentration ...	20.42	12.54
Check (Untreated) ...	10.39	3.56
Significant difference at 5% level ...	11.64	...

Whiz gave a high kill of active forms and was significantly superior to all other treatments. HRS. 836 and HRS 2271 were only slightly effective, there being no significant difference between them, whereas HRS 920 was not better than check.

Sub-Table II

Treatments	Percent active forms killed (transformed into angles)	Percent active forms killed.
Dimite at 1 in 800 parts water ...	49.12	56.94
HRS. 836 (20% W. P.) at 0.5% concentration ...	29.48	24.88
Check (Untreated) ...	5.42	1.22
Significant difference at 5% level ...	8.52	...

Dimite gave a moderate kill of active forms. HRS. 836 was only slightly effective.

Sub-Table III

Treatments			Percent active forms killed (transformed into angles)	Percent active forms killed.
R. 6199 (10 ppm. water)	...	...	63.05	79.42
R. 6199 (20 ppm. water)	...	...	62.26	71.30
R. 6199 (40 ppm. water)	...	...	55.64	68.02
Check	...	...	4.17	0.70
Significant difference at 5% level			6.03	...

R. 6199 at its three concentrations was found to be effective against active forms of Red spider but the concentration of 40 ppm. was significantly inferior to other concentrations.

Sub-Table IV

Treatments			Percent active forms killed (transformed into angles.)	Percent active forms killed.
R. 6199 (20 ppm. water)	...	...	58.02	66.76
R. 6199 (40 ppm. water)	...	...	48.35	55.72
R. 6199 (10 ppm. water)	...	...	44.70	48.34
Check	...	...	4.64	1.62
Significant difference at 5% level			18.32	...

In this trial also all the three concentrations of R.6199 proved to be effective, there being no significant difference amongst them.

Table 14—Red spider Control—E. Residual effect on active forms

Treatments			Percent active forms killed (transformed into angles).	Percent active forms killed.
Whiz (with 4% Thanite) at 1 in 80 parts water	...	...	7.19	2.0
Check	...	...	10.88	3.6

Treatments are not significant.

Whiz (with Thanite) appears to have little residual effect on active forms.

A field trial was conducted with Malathion 50% E. C., Malathion 20% W.P., and HRS. 836 against Red Spider at Tocklai. The treatments were applied by means of Pressure-retaining Knapsack Sprayers fitted with low volume nozzles, using approximately 100 gallons of spray per acre.

Table 15—Red Spider Control—Field Trial.

Treatments	Red spider population per 10 leaves, 1 week after treatment. (Mean of 4 replications).	Percent reduction over Check.
Malathion 50% E. C. at 1 in 400 parts water	1016.75	55.22
Malathion 20% W. P. at 1 lb. in 20 gallons water	1341.00	40.94
HRS. 836 at 1 lb. in 20 gallons water	910.50	59.90
Check	2270.50	...
Significant difference at 5% level	477.69	...

Malathion E. C., Malathion W. P., and HRS. 836 showed effective reduction in Red spider populations, there being no significant difference amongst the treatments.

Another observation was made five weeks after treatment, but as most of the Red spiders were washed away by rain, there was no significant difference amongst the treatments.

Evaluation of residues of Pesticides on made tea :

A large number of samples of sun-dried as well as made teas from plots treated with Akar, Aramite and Endrin have been sent to respective manufacturers of the pesticides for evaluation of residues.

Tainting effect on made tea :

The following samples of made tea from plots treated with Akar, Aramite and Endrin were tasted by our Tea Taster whose report is given below :

Table 16 : Tainting Effects

Treatments.	Date of treatment.	Date of plucking.	Sample No.	Total rainfall	Taster's comments.
(a) Aramite 15W at 1 lb. to 50 gallons water.	31-8-56	31-8-56	1A	Nil	Badly tainted.
Check (Untreated)	...	31-8-56	1B	Nil	No taint.
(b) Aramite 15W at 1 lb. to 50 gallons water.	19-9-56	25-9-56	2A	Nil	No taint.
Endrin 19.5 E. C. at 1 in 1000 parts water	20-9-56	27-9-56	2B	Nil	Slight plywood taint.
Akar, 1 in 500 parts water	20-9-56	27-9-56	1	Nil	Not tainted but very old in cup and out of condition.
Check (untreated)	...	25-9-56	...	Nil	No taint.

Leaf-rollers and Leaf-tiers of tea :

Preliminary studies on the history, nature of damage and biology of the leaf-rollers and leaf-tiers, with special reference to Flushworm (*Laspeyresia leucostoma*) have already been made and a report will be submitted shortly. Further studies on the life-history, alternate hosts, natural enemies, and the effect of the persistent toxic insecticides on the pests as well as on their natural enemies are being made.

Flushworm (*Laspeyresia leucostoma* Meyr.). —The Flushworm was not considered to be a major pest until sudden sporadic outbreaks of it occurred in Cachar and Darjeeling this year. The caterpillar ties up a few top leaves and feed inside. The damage thus caused is considered to be more serious than that

caused by any leaf-rollers or tiers. The damaged shoots have to be discarded altogether as it affects the quality of tea. The Flushworm is often mistaken for Tea Tortrix but can be easily recognised from the latter by the nature of damage and larval characters. The larva of the Flushworm has a black 'cheek spot' on each side of the head behind the eyes, the head and the body being yellow in colour, while the larva of Tea Tortrix has a black head, the 'cheek spot' being absent.

New Leaf-roller (*Striglina glareola* F.).—Hitherto unrecorded, this insect is occasionally found on tea bushes particularly on lateral branches. Instead of passing the first larval stage as a leaf-miner like *Gracilaria thievora*, it starts rolling the leaf immediately after hatching out. An incision is made at the margin somewhere near the base and the distal portion is spirally rolled up along its length.

Nest-forming caterpillar (*Sylepta balteata* F.).—This insect was discovered on tea bushes sometime ago, but it is not considered a pest at all. It however attacks a large number of forest trees. The caterpillar at first rolls up the leaf in the manner as *Striglina glareola* does, but as it grows bigger more leaves are drawn in one by one, rolled over it and fastened at short intervals with thick white silken cords.

Incidence of pests on Nursery Shade Plants :

Observations on the incidence of various pests on nursery shade plants was continued for the second year and the summarised results are as follows :—

Rhesala moestalis.—This green caterpillar occurred in a severe form on *Albizzia lebbek*, *A. procera*, *A. odoratissima*, *A. stipulata* whereas *Adenanthera pavonina* was slightly attacked.

Psyllids.—*A. lebbek* and *A. procera* plants were severely damaged by Psyllids whereas *Dalbergia assamica* was slightly attacked.

Mealy bug and Red Ant.—*A. stipulata*, *A. procera*, *D. assamica*, and *Cassia laevigata* were attacked by a

Mealy bug, imprisoned by the common Red ant in its nests.

Surendra quercetorum.—This Lycaenid caterpillar was occasionally quite prevalent on *A. odoratissima* and *A. moluccana*.

Leaf-eating beetles.— *D. assamica* and *A. stipulata* were severely attacked by some leaf-eating beetles whereas *A. odoratissima*, *A. procera*, *D. robusta* and *A. moluccana* were slightly damaged.

A number of other insect pests such as Membracids, *Agrilus beelsoni*, *Coptosoma* bugs, Green weevils, Hairy caterpillars, Jassids, Aphids, Orange beetle, *Lawana conspersa*, Grass hoppers etc. were also found to occur occasionally on most of the shade tree spp., but the damage caused by them was negligible.

SCIENTIFIC PUBLICATIONS

- (1) "New Psychids (Lep. Psychidae) from Assam," by G. M. Das—Annals and Magazine of Natural History, London, Vol. IX, 1956.
- (2) "Psychidae (Lepidoptera), on tea in North-east India," by G. M. Das—Annals and Magazine of Natural History, London, Vol. IX, 1956.
- (3) "On the Association of Red ant, *Oecophylla smaragdina* Fabr., with the tea coccid, *Coccus hesperidum* L.," by R. N. Ganguli—Proceedings of the 44th Session of the Indian Science Congress, Calcutta, 1957 (Abstract).

ADVISORY

Touring.— The Senior Entomologist visited Singell, Ging, Rungneet, Chongtong, Nagri and Tumsong in Darjeeling, Bormahjan in North Bank, Silcoorie, Binnakandy, Burnie Braes and Borokai in Cachar, Tyroon, Cinnamara and Hunwal Tea Estates in Upper Assam, and his assistants visited Sam Sing in Dooars, Julia, Dufflaghur and Sapoi in North Bank,

Koomtai and Behora in Upper Assam and Silcoorie T.E. in Cachar in connection with pest control.

Correspondence.— 284 letters and memoranda were issued.

Specimens.— 100 samples of insects and affected plants were received for examination and report.

Pesticides.— 19 samples of pesticides were received for tests.

Publication.— The following were published :—

- (1) Compatibility of Insecticides, Acaricides and Fungicides commonly used in tea—Tea Encyclopaedia Serial No. 110, under J. 3.
- (2) Ants and Their Nests—Tea Encyclopaedia Serial No. 112, under J. 3.
- (3) Scale Insects and Mealy bugs on tea bushes—Tea Encyclopaedia Serial No. 113, under J. 3.
- (4) Insect found inside Tea Chests on arrival in U.K.—“Two and a Bud,” June 1956.
- (5) Toxicity of Pesticides, jointly with Mr. Glover—“Two and a Bud,” December, 1956.

GENERAL REMARKS

Pest Incidence.—Red spider attack persisted up to the middle of the second quarter. Outbreaks of Looper occurred in the North Bank and Golaghat district. Incidence of Rim blight following Jassid attack was common throughout Upper Assam. Sporadic outbreaks of Flushworm were reported from Cachar and Darjeeling. A Noctuid caterpillar, *Ophiusa* sp. and a Eumolpid beetle, *Trichochrysis hirta* caused damage to shade trees in localised areas.

PLANT PATHOLOGY BRANCH—MYCOLOGICAL SECTION

K. C. SARMAH—Mycologist

STAFF

Dr. V. Agnihothrudu, M.A., Ph.D., joined the department as Senior Assistant on 8th October. Shri P. Hatibaruah, typist, has retired on 31st December after 40 years service with the Indian Tea Association.

RESEARCH AND EXPERIMENT

1. Screening of Fungicides :

The effect of 5 copper fungicides against Black rot of tea was tested in the field at Dibru-Darrang T. E. (Section No. 10). All the fungicides, stated to contain 50% copper, were used at 0.25% concentration (1 lb. fungicide in 40 gallons of water).

The experimental area known to be affected by Black rot, consisted of 6 blocks of 6 plots each ; plots contained $5 \times 10 = 50$ bushes in each.

In each block there were 6 randomised treatments including a control. Spraying applications were made on 2 occasions, once in the 3rd week of April and again in the 2nd week of May.

Assessment on the incidence of the disease was made on 3 occasions between 1st of July and 10th of September, by giving points to individual bushes in the following order :—

- 0 for no infection.
- 1 ,, slight infection.
- 2 ,, moderate infection.
- 3 ,, severe infection.

Results of all the three assessments (averaged) have been tabulated below :—

Average infection per bush

Table 1 :

Treatments.	BL-1	BL-2	BL-3	BL-4	BL-5	BL-6	Total.	Average.
1	·28	·37	·56	·38	·51	·80	2·90	·48
2	·59	·58	·21	·37	·37	·33	2·45	·41
3	·60	·60	·58	·58	·45	·77	3·58	·60
4	·55	·75	·36	·66	·32	·69	3·33	·55
5	·61	·60	·36	1·04	·47	·53	3·61	·60
6 Control	1·18	·85	·90	1·05	·95	·89	5·72	·95

Analysis of Variance.

V. due to	Sum of Sq.	D of F	Mean
Treatment ...	1·06	5	0·21 Significant.
Block ...	0·21	5	0·04
Error ...	0·64	25	·03

SD=0·20

The effect of treatment was significant in all cases.

The suspensibility and dispersibility of 2 of the fungicides were not satisfactory.

In the above estate, section No. 10 areas 1 and 2, which were prophylactically sprayed against Black rot in the preceding year with two copper fungicides (Perenox and Coppesan), the treatments were repeated in 1956. 2 applications were made during the prophylactic period, once in the 1st week and again in the 3rd week of May.

The treatments as in the previous year effected highly significant control of the disease. With these 2 fungicides, addition of a spreader made no difference.

The incidence of the disease in the second year of prophylactic treatment indicates that although high reduction can be effected by such treatment it is not enough to eradicate the

disease from an affected area. It therefore becomes necessary to treat individual affected bushes palliatively later on (*vide* T.E. Serial 8/2 filed under 1.3, page 3, para 3).

The Manager's assistance in these trials is very much appreciated.

2. Chemical control of Brown Root Rot (*Fomes lamaoensis*) and Charcoal Stump Rot (*Ustulina zonata*) :

'Crag fungicide 974' (3.5 dimethyltetrahydro -1, 3, 5, 2H thiadiazine 2 thione) was used against the above fungi in the laboratory as well as in the field.

Laboratory trials.— (a) Pieces of tea root attacked by Brown root rot and Charcoal stump rot were placed in a covered glass jar containing the above fungicide @ 200 lbs. per acre of soil (depth 15") at the bottom ; the diseased materials were supported about an inch above the fungicide. A control jar was kept alongside.

20 Plate cultures were made on synthetic media from each of the treated and untreated materials after an interval of 1 month.

The results were as follows :

Table 2

Total colonies sown with.			Total colonies producing fungal growth	REMARKS.
Treated	Charcoal stump rot ...	20	20	In some cases the growth of Charcoal stump rot was masked by other fungi.
	Brown root rot	20	16	
Control	Charcoal stump rot ...	20	20	-do-
	Brown root rot	20	16	

(b) Pieces of wood affected by Brown root rot and Red root rot (*Poria hypolateritia*) were buried in a boxful of soil treated with 'Crag 974' at the rate of 200 lbs. per acre worked

to a depth of 4". The soil was kept moist. Examined after 2½ months both the fungi were found to develop fresh mycelial growth.

(c) 2 bushes attacked by Brown root rot were treated by sprinkling 1½ oz. of 'Crag 974' around each bush in an area of 4' square × 15" deep (*i.e.* @ 200 lbs. per acre) in a Dooars garden. The bushes were obtained after being in situ for 2½ months. Cultures made from affected material showed that the fungus was not killed.

2 bushes attacked by Charcoal stump rot were treated as above in the field at Tocklai on 29.8.55. The fungus was alive on the bushes in November, 1956, *i.e.* after about 14 months.

(d) 4 plots of 7' x 4' each were prepared and treated with 'Crag 974' in the following way. The fungicide was mixed with the soil to a depth of 15".

Treatment 1 — Control.

„ 2 — 'Crag 974' at the rate of 200 lbs. per acre.

„ 3 — 'Crag 974' at the rate of 400 lbs. per acre.

„ 4 — 'Crag 974' at the rate of 600 lbs. per acre.

Tea roots affected by Brown root rot and Charcoal stump rot were buried at 0"-5", 5"-10" and 10"-15" from the surface.

After 2½ months cultures were made on synthetic media with diseased material from the 3 depths of soil in treatments 1 and 3 and the fungi were found to be alive. At the same time diseased material from treatments 1 and 3 was used for inoculating 36 young plants in a separate area. Healthy young plants were also planted in contact with diseased material in all the above 4 plots. Some of the latter were killed out by drought after about 5 months. These showed no evidence of the diseases.

After an interval of about 12 months a few plants died out as a result of attack by the two fungi (Brown root rot and Charcoal stump rot) in some of the plots. It is hoped that it will be possible to form some conclusion during 1957. Preliminary results however do not show much effect of the fungicide.

3. Tea flower disease (*Sclerotiniaceae*) :

Inoculation experiment.—An experiment was carried out to test the infectivity of the conidial stage (*Botrytis*) of the tea flower disease. This type of fructification is found practically on every dead tea flower, during the flowering season not only on tea seed trees but on all teas bearing flowers. The occurrence of this stage of a fungus belonging to the *Sclerotiniaceae* family, initiated the belief that non-setting of tea flowers resulted from attack of the blossoms by *Sclerotinia*. It is however not definitely known whether these conidiospores are responsible for the infection of healthy flowers, thus causing them to fall, or whether they occur as a result of secondary infection on flowers which are about to fall due to some other cause.

Unopened but fully grown flower buds were hand pollinated and inoculated with spore suspensions obtained from pure culture.

Six different clonal seed bearers were selected, viz. (1) 4.10, (2) 5.4, (3) 114.2, (4) 19.29.13, (5) 19.39.7 and (6) 30.1.

Pollen was used from two sources (1) Kharikatia No. 5.9 and (2) China No. 14.1.5

- Treatment* :
- (1) Pollinated, and immediately enclosed in a muslin bag (control).
 - (2) Pollinated, sprayed with a heavy spore suspension of *Botrytis* stage and enclosed in muslin bag.
 - (3) Pollinated, sprayed with spore suspension of *Botrytis* stage, followed, after 1 hour, by Fernide spray at 0.25% concentration and enclosed in muslin bag.

50 Flowers taken for each source, i.e. 50×2 sources $\times 3$ treatments $\times 6$ clones = 1800.

The flower buds could not be sterilised prior to inoculation but the amount of infection from nature, if any, was assumed to be equal in all cases. The work was commenced on 16.12.55 and continued till 13.2.56. The bags were removed after about

a month. Total numbers of set fruits were counted on 31.5.56. The following table shows the number of fruits set, out of 50 in each case.

Table 3.

Plant No.	Treatments.								
	1		2		3		Total.		Total.
	China 14.1.5	Khari- katia. 5.9	China 14.1.5	Khari- katia. 5.9	China 14.1.5	Khari- katia. 5.9	China 14.1.5	Khari- katia. 5.9	
19.29.13 ...	19	10	22	39	11	9	52	58	110
19.39.7 ...	17	19	13	28	11	13	41	60	101
114 2 ...	6	8	10	5	6	10	22	23	45
30.1 ...	0	2	2	3	10	2	12	7	19
5.4 ...	2	8	2	8	4	14	8	30	38
4.10 ...	5	17	8	5	1	9	14	31	45
Total seeds set out of 300 ...	49	64	57	88	43	57	149	209	358
Total seeds set out of 600 ...	113		145		100				

Results are not statistically significant. It appears that under the conditions of this experiment, inoculation with conidiospores (*Botrytis* stage) obtained from culture, did not affect fertilisation of the flowers and setting of fruits.

Spraying experiments.— A large scale spraying field trial, as a supplement to the above was organised by the Senior Advisory Officer, Assam, at Dhelakhath T. E. The substance used for spraying was Tetramethyl thiram disulphide, commercially known as Fernide—a product manufactured by Messrs. Imperial Chemical Industries Ltd. It was used at 2½ lbs. per 100 gallons of water to which 2 ozs. of Teepol 710 was added as a spreading and wetting agent.

The field trial area consisted of 6 plots of 280 trees each (approximately 2.07 acres each) : 3 alternate plots were sprayed on 4 occasions at intervals of 10-12 days, during November-December, 1955 and the other 3 were kept as control. Applications were made with a Universal Major Power sprayer using about 180 gallons fluid per acre.

In the sprayed area the net gain in saleable seed per acre was 1.48 maunds.

Details of the experiment are given in the Senior Advisory Officer's report. It would appear from the results of this trial that it would be worthwhile taking up another large scale field trial in 1957 for confirmation, provided sufficient fungicide could be made available by the firm for this purpose.

A second experiment was carried out at Butlikhowa tea seed bari (Hautley T. E.) in Golaghat.

The following nine treatments as detailed in table 4 were applied from the end of October, 1955 to middle of December, 1955. Three rows of four trees with 3 randomised replications for each treatment were used so that the number of plants per treatment was $4 \times 3 \times 3 = 36$.

Table 4.

Treatments.	Spraying.	Ground treatments.		Dates of application.	Cultivation.
		Watering.	Dusting.		
1	Fernide : 0.25% soln. + spreader.	...	...	Nov. 3, 11, 21 & 30. Dec. 12th.	Soil surface cleaned in October.
2	Crag 658 : 0.25% soln. + spreader.	...	...	"	"
3	No fungi- cide.	...	...	...	"
4	...	Fungex 0.625% soln.	...	Oct. 20/21 Nov. 21/22 Dec. 21/22	"*
5	...	Oil soluble Mercury fungicide 0.31% soln.	...	"	"*
6	...	Phenyl Mercury- Chloride 0.2% soln.	...	"	"*
7	...		Copper sandoz dust 6%	"	"*
8	...	...	...	...	"*
9	...	...	...	...	No cleaning was done.

*In addition to surface cleaning the plots were lightly forked to 1½" one week before treatment i.e. on 14/15 Oct. 14/15 Nov. 14/15 Dec. 1955.

Seed collection was made by the Estate in November, 1956. Total amounts of seed obtained from the different plots are given below in table 5.

Table 5.

Treatments.	Yield—Total of 3 blocks.		Total Nos of Bushes.
	Md.	Sr.	
1	1	13 $\frac{3}{4}$	35
2	1	12	33
3	1	13 $\frac{1}{2}$	31
4	1	8 $\frac{1}{4}$	35
5	1	$\frac{1}{4}$	34
6	1	18	34
7	1	29 $\frac{3}{4}$	33
8	1	14	36
9	1	1 $\frac{1}{4}$	34

Statistically none of the treatments was found to be significant.

Another small area at Hautley T. E. was divided in the middle into 4 sectors. Two diagonal plots were sprayed, by the management, with 0.25% Fernide on 4 occasions at intervals of 10-12 days during November-December, 1955. Total seed obtained from the areas was as follows :—

Sprayed area—2 maunds 27 seers.

Unsprayed „—2 „ 8 „

The managements' assistance in the above trials is hereby gratefully acknowledged.

4. Experiment on the control of Eelworms with Shell D-D soil fumigant :

Three large scale field experiments were conducted jointly by Messrs. Burmah Shell and Tocklai, in 3 different regions of North East India. The experiments were laid out and designed by Messrs. Burmah Shell. Tocklai's share in the trials was that of estimating eelworm populations in the soil before and after treatment and examination of tea seedlings from the beds after 6-7 months for eelworm infestation of the roots. The latter involved examination of 5,000 individual seedlings.

Sites chosen and time of treatment.

Place	Treated.	Untreated.	Time of application.
(1) Behubor T.E. (Nazira)	1½ acre	½ acre.	9th—11th Sept. 1955.
(2) Monabarie T.E. (N. Bank)	1 „	½ „	21st—22nd Sept. „
(3) Bhogotpore T.E. (Dooars).	1 „	½ „	10th—14th Oct. „

Application of the fumigant : Shell D-D was applied at the rate of 400 lbs. per acre with shell injector gun at staggered spacings of 15" (*i.e.* 15" × 15" triangular). The soil surface was partially sealed either by watering or rolling immediately after application in order to minimise the escape of the fumigant. To eliminate the possibility of the seedlings being damaged by soil borne insects and termites both the treated and the control areas except at Monabarie were treated at the same time with 5% Shell Aldrin dust broadcast at the rate of 80 lbs. per acre.

In order to prevent cattle or trespassers introducing outside contamination of the eelworms experimental areas were properly fenced with only one entrance gate. A weak solution of Hypochlorite was used for disinfecting the feet of workers entering into the areas after treatment.

Sowing of seeds.— The beds were aerated by raking the soil about 3-4 weeks after treatment. Seed was sown and the nurseries were maintained according to the usual garden practice.

Eelworm populations.—Eelworm counts in the soil were made prior to treatment, 4 weeks after fumigation and at the time of examining the seedlings. Acidity was also determined by the Physico-Chemical Branch. Figures are given below in table 6.

Examination of seedlings:— Seedlings were uprooted from random patches by throwing an one foot square frame on to the

Table 6.

Gardens.	Treatments.	No. of eelworms per 10 gms of soil			pH		
		Before treatment.	4 weeks after treatment.	At the time of examination of roots.	Before treatment.	4 weeks after treatment.	At the time of examination of roots.
Behubor	Treated	11	7	3	4.52	4.56	4.36
	Untreated	9	27	7	4.96	4.84	4.91
Bhogot-pore.	Treated	40	8	8	5.14	5.16	5.03
	Untreated	31	80	8	5.31	5.33	5.17
Monabarie.	Treated	26	3	4	5.89	5.55	5.47
	Untreated	50	15	13	5.04	5.14	5.33

nursery. Intensity of eelworm infestation was recorded by putting

- 0 for no infestation.
- 1 for slight infestation.
- 2 for moderate infestation.
- 3 for severe infestation.

Results are tabulated below :

Table 7.

Gardens.	Date of examination.	Average degree of infestation per 100 plants.		Average weight of 100 plants in lbs. & ozs.	
		Treated.	Untreated.	Treated.	Untreated
1. Behubor	25.7.56	38.8	43.6	3-0	2-8
2. Bhogotpore.	11-7-56— 15-7-56	37.0	42.9	1-3*	1-8*
3. Monabarie.	13-8-53— 16-8-56	33.4	47.5	4-0	3-15

*The weight of the plants was very low since much of the foliage had fallen off as a result of sun-scorch damage.

The results were not statistically significant.

N.B. All work on the control of eelworms and examination of soil samples has been taken over by the Entomological section, from 1st of January, 1957.

SCIENTIFIC PUBLICATIONS

“Tylose Formation in Tea”—Indian Phytopathology, Vol. IX, Number 1, July 1956, pp. 23-30.

ADVISORY

Touring.—The Mycologist visited 19 gardens (6 in Cachar and the rest in Assam Valley) in connection with disease control.

Lectures and Demonstrations.—The Mycologist read a paper on “Some Pathological considerations Related to Pruning” in the thirteenth annual conference. Mr. H. Mitra, Additional Advisory Officer received training in the Mycology Section for two weeks during September and again for one week in November. 8 apprentices took their training in Mycology in two shifts, 16th to 31st October and 1st to 15th November.

Examination of specimens and samples.—The following were received for examination.

(1) Diseased specimens of tea, shade plants and green crops	...	...	1271
(2) Soil samples for eelworm test	...	...	404
(3) Water samples for bacteriological test	...	...	66
(4) Tea seed samples (not for export)	...	...	5
(5) Plant protection products for trial	...	...	2
TOTAL :—			1748

Correspondence.—457 letters and memoranda were issued in connection with the above samples and disease control.

Publications.—(a) “A note on the use of *Stylosanthes guyanensis* Sw. var *gracilis* (H.B.K.) Vog. in Relation to Black Rot Disease of Tea”—“Two and A Bud”, Vol III No. 4, December, 1956.

(b) “Some Pathological considerations Related to Pruning”—“Two and A Bud”, Vol III No. 4, December, 1956, (this was read in the thirteenth annual conference).

GENERAL REMARKS

1. Blister blight :

Incidence of the disease was reported from the following number of estates.

	Assam.	Cachar.	W. Bengal.
January	5+1 (Tocklai)	1	—
February	—	1	—
March	—	—	—
April	3	1	—
May	2	1	—
Oct.	—	—	1
Nov.	1	—	2
Dec.	3	1	2

In the third week of January Blister blight was suddenly noticed on one bush in the China plot adjoining the Tocklai laboratories. A thorough bush to bush search was made immediately in all the plots but no further evidence of the disease was noticed.

The Senior Advisory Officer in West Bengal observed that owing to appreciable quantities of rain at intervals during the month of November and December there was considerable evidence of Blister blight in a number of varied localities in the Dooars.

The above mentioned estates reported that satisfactory control of the disease was achieved by the application of appropriate methods as given in the T.E. Serial No. 62/1 filed under I.3.

There was no incidence of Blister blight from June to September.

2. Sun-scorch :

During the period from about the end of June to the middle of July most of the Upper Assam gardens were subjected to a hot, dry spell. As a result most of the fully opened, mature leaves on the top canopy, especially in poorly shaded areas, were affected by sun-scorch. This damage was followed by a severe attack of Brown and Grey blights. In severely affected areas raising of the plucking table by leaving a leaf was recommended.

3. Probable variation in the time of prophylactic treatment against Black rot and Red rust :

In 1955, the Advisory Officer of Cachar observed that the Black rot fungus manifested itself on the new growth of tea by about the end of March and fully developed Red rust fructifications also appeared about the same period. Such behaviour of the two diseases is sometimes possible under unusual climatic changes. For instance Red rust fructifications in 1955 appeared in the Dooars and Upper Assam somewhat later than the usual period. However, it was considered important to ascertain whether the prophylactic period varied always in the Cachar District from the rest of North East India. Accordingly a special visit was paid by the Mycologist to investigate the matter jointly with the Advisory Officer, Cachar, in early April (4th—9th), 1956.

Black rot.— Microscopical examination of shoots collected from bushes known to be affected by Black rot in the past showed that the fungus was just starting its regrowth. It was traced along the new stems to about an inch from its base. It appeared therefore that given suitable conditions for its development the fungus would reach the lowest leaf on the shoot by about the middle of April when the prophylactic period of spraying commences according to T.E. Serial No. 8/2 under I.3.

Red rust.— As was the case at Tocklai, Borbhetta and a few other neighbouring places fruiting hairs of Red rust were making their appearance on the affected stems, but the sporangia were still to be formed at the time of observation on the 5th April. Even such hairs were noticed only on tea which had received no treatment in the preceding year. Both fruiting hairs and variegation of the leaves were absent at the time on young tea which was sprayed with Perenox on three occasions during the prophylactic period in the previous year. It appeared that the peak period of fructification would not be in advance of that given in T.E. Serial No. 61/1 under I.4.

4. Important diseases :

Routine record on the incidence of important diseases of tea and shade trees, built up from examination of diseased specimens received at Tocklai and from the observations made by the Advisory Officers shows the places of occurrence as given below :—

Table 8

Diseases.	Assam Valley.	Cachar.	Dooars.	Darjeeling.
1. Charcoal stump rot*	16	9	3	3
2. Brown root rot. ...	10	...	1	2
3. Red root rot ...	1	...	...	...
4. <i>Poria hypobrunnea</i> ...	23	4	5	7
5. <i>Nectria</i> sp.	1	...	...	...
6. Black rot ...	27	14	...	1
7. Blister blight ...	15	5	5	...
8. Red rust (<i>Cephaleuros parasiticus</i>)	38	20	5	...

*The disease was observed on tea in Ranchi by the Senior Advisory Officer, Assam, and a specimen was collected by him for confirmation.

5. Incidence of diseases on hosts other than tea :

The following fungi have been recorded on shade and green crop plants.

1. *Auricularia auricula* (L) Schr. on 3 year old *Tephrosia candida* Stump.
2. Black rot (*Corticium invisum*, Petch) on *Albizzia amara* and *A. stipulata* (= *A. Chinensis* (Osbeck) Merr).

Black rot (*Corticium theae*, Bern) on *Stylosanthes guyanensis* Sw. Var. *gracilis* (H.B.K.) Vog.

3. Pink disease (*Corticium salmonicolor* B & Br.) on *Crotalaria anagyroides*, H.B.K.
4. *Corticium* sp. (*C. solani*) on *Crotalaria anagyroides* and *Centrosema plumieri*.
5. *Camptomeris* sp. on *Albizzia odoratissima* (L.) Benth., *Albizzia procera* (Roxb.) Benth. and *Albizzia stipulata* (= *A. Chinensis* (Osbeck) Merr).
6. A rust fungus (*Ravenelia clemensae*, Syd.) on leaves of *A. Procera* (Roxb.) Benth.
7. *Nectria* sp. (*Cylindrocarpon conidia*) on *Albizzia procera*.
Nectria sp. on *Albizzia moluccana*. = *A. falcata* (L) Backer.
8. Violet root rot (*Sphaerostilbe repens* B. & Br.) on *A. odoratissima* and *Gliricidia sepium* (Jacq.) Steudl. (= *G. maculata*).
9. *Fusarium* sp. on *Gliricidia sepium*, *Crotalaria anagyroides* and *Albizzia moluccana*.
10. Brown root rot (*Fomes lamaoensis*, Murr. = *F. noxius*) on *Hibiscus*.
11. *Phomopsis* sp. on *Albizzia moluccana*.
12. Red rust (*Cephaleuros parasiticus* Karst) on *Desmodium gyroides* (Roxb. ex. DC.) Benth.

Crotalaria anagyroides, H.B.K.—A severe attack of Pink disease (*Cort. salmonicolor*) on 2 year old *C. anagyroides*, grown as green crop shade, in a 6 acre tea nursery was noticed in a garden in Golaghat in the last week of September, 1956. A few weeks later it was observed at Borbhetta and in Upper Assam on the same host but to a lesser extent. Young tea plants growing underneath the affected *Crotalaria* were unaffected. The disease was recorded on *Crotalaria* in the past but its occurrence was rare and limited. Affected plants were

promptly removed and the tea sprayed prophylactically with Copper fungicide where possible.

Desmodium gyroides (Roxb. ex DC) Benth.— In April, the Mycologist in course of his investigations in Cachar, on the development of Red rust fructifications on sprayed and unsprayed tea *vis-a-vis* the prophylactic spraying period, noticed the disease on 2 year old *Desmodium gyroides*. It was reported also from the Dooars on the same host to occur in a severe way. In December, 2 year old *Desmodium gyroides* in a neighbouring garden was found to be very severely attacked by Red rust. This green crop seems to be extremely susceptible to the disease. It has now been decided to recommend its use in young tea, in Red rust susceptible areas, only as a one year old crop.

Stylosanthes guyanensis Sw. var. *gracilis* (H.B.K.) Vog.— In September 1955 a slight attack of this green crop by *Corticium invisum*, Petch, was found on a specimen from a Golaghat garden. In October 1956, sporadic attack by *Corticium theae*, Bern, was found in young tea areas in 2 local gardens where the disease spread from the affected Stylo to the adjacent young tea. In one of the gardens it occurred over a considerable area. *Stylosanthes* is not only very susceptible to Black rot, it can also serve as a source of infection to young tea. Precautionary measures on its use in Black rot susceptible areas have been suggested in "Two and a Bud", Vol III, No. 4, December 1956.

Albizzia moluccana = *A. falcata* (L) Backer.— A certain amount of die-back of the stems, in a 2 year-old nursery, was noticed in a local garden. The nursery area contained several pits about 6 to 7 feet in diameter and of similiar depth and the soil at the time was very hard and dry, even at the bottom of the pits. It appeared to be a case of water shortage. Affected stems however revealed the presence of 3 fungi—*Phomopsis* sp., *Nectria* sp., and *Fusarium* sp.—and a bacterium. These were isolated in culture and used for inoculating the stems of healthy *A. moluccana* plants grown in the station, once in March and again in November. There was no sign of infection till the end of the year. It would therefore appear that the microorganisms were not responsible for the die-back.

BACTERIOLOGY

Bacteriological tests of the Tocklai water supply were made twice a week throughout the year.

Results, as monthly averages, are given below :

Table 9 :

Months	Untreated water.		Treated water.		Remarks.
	Total bacteria per c. c.	Lactose fermenters per c. c.	Total bacteria per c. c.	Lactose fermenters per c. c.	
Jany.	42	1	1	0	
Feby.	0	0	0	0	Tube well supply
March	0	0	0	0	„ „
April	0	0	0	0	„ „
May	0	0	0	0	„ „
June	82	64	0	0	Tank supply.
July	205	182	8	8	„ „
August	125	105	0	0	„ „
Sept.	57	36	0	0	„ „
Oct.	24	6	0	0	„ „
Nov.	39	5	1	0	„ „
Dec.	12	2	0	0	„ „

In addition to the above, 66 samples of water were received from outside estates for bacteriological tests.

BIOCHEMICAL BRANCH

D. J. WOOD—Senior Biochemist

N. B. CHANDA—Assistant Biochemist

STAFF

Dr. N. B. Chanda was on study leave in the U.K. from July to September, during which time he worked for eight weeks at Edinburgh University and paid visits to East Malling Research Station, Cambridge University and the I. T. A. Chemical Laboratory, Butler's Wharf.

Mr. Md. R. Ullah and Mr. M. N. Dev Choudhury joined the Branch as Senior Grade Assistants (Technical) on the 14th May and the 13th August respectively.

RESEARCH AND EXPERIMENT

FUNDAMENTAL RESEARCH

Rate of Moisture Loss During Withering :

Observations similar to those mentioned in the Annual Report for 1955 have continued. The rate of moisture loss of eleven *jats* was measured under standard conditions on fourteen occasions from the end of May to the end of September, and at the same time various physical characters of the shoots were recorded. On average over the season the rate of the fastest withering *jat* was 11% higher than that of the slowest, but on individual occasions much greater fluctuations were observed, the greatest being 28%. Also, as was observed in 1955, the rate of individual *jats* relative to the mean rate of all the *jats* fluctuated very considerably. For instance the relative rate of one *jat* fluctuated from 1.17 to 0.87, with a mean of 0.99. There was in addition an overall seasonal change in the rate of withering, which rose steadily from May to the end of August and then fell away again, the rate at the end of August being 40% greater than that in May. None of the physical characters recorded could be related either to the mean rate of a *jat* or to its periodic fluctuations.

So far there appears to be no way of predicting the withering rate of a bulk of leaf under standard conditions, such as by knowledge of its *jat* and by simple physical measurements. In tunnel withering, or other forms of controlled withering, such prediction would have obvious advantages. The results only emphasise that the withering rate can vary within fairly wide limits in an unpredictable manner. This being the case it would seem advisable in controlled withering to provide some means of following the actual extent to which the leaf has withered without interrupting the process. If this is not done, but the process is merely allowed to continue for a standard length of time, the degree of wither obtained may on occasions be very different from that aimed at.

Chemical Changes in Withering :

Studies relating specifically to the increase of caffeine during withering have had to be deferred due to priority of other work. However certain incidental information which has come out of the investigation designated "Chemical Basis of Quality" (reported below) is included here as it has a direct bearing on the subject. In Table 1 figures for water-soluble nitrogen, caffeine nitrogen and "other soluble nitrogen" (by difference) in the leaf from four areas at Borbhetta are compared with figures for the increase in these same nitrogen fractions brought about by natural overnight withering (duration approx. 24 hours). All figures, including those for increase, are percentages based on the dry weight of the original fresh leaf.

Table 1

Area		33	34	21	2A
Fresh Leaf	Soluble N	1.661	1.965	1.974	2.132
	Caffeine N	.967	1.129	1.164	1.160
	Other N	.694	.836	.810	.972
Increase During Withering	Soluble N	.171	.188	.185	.167
	Caffeine N	.051	.070	.118	.112
	Other N	.120	.118	.067	.055

The increase in water-soluble nitrogen is approximately the same for all four areas and bears no relation to the initial content of water-soluble nitrogen. The increase in caffeine, on the other hand, is not the same for all four areas but follows the same order as the initial caffeine content. If the enzyme systems responsible for synthesis of caffeine in the fresh leaf are still active during the period of withering this observation is not altogether unexpected. In view of the fact that in this experiment, as reported below, the caffeine content was shown to be correlated with Tasters' assessments of the liquor, the changes in caffeine during withering are possibly of considerable importance. Similar experiments which are planned for 1957 will help to show whether or not these two phenomena—the relation between caffeine increase and caffeine content and between caffeine content and quality—are of general occurrence.

That fairly complicated metabolic processes are still active in the plucked shoot has been shown by a few simple experiments in which shoots have been infiltrated with various chemicals—chiefly amino-acids—and the effect on the amino-acid content observed. Protein breakdown during withering, with accumulation of amino-acids, has been recognised for a long time. It has seemed puzzling however that certain common amino-acids, notably glycine and hydroxyproline, are never observed on paper chromatograms of withered leaf except very occasionally in trace amounts. We have now shown that both these amino-acids are present in an acid hydrolysate of tea leaf protein. Plucked shoots infiltrated with glycine for 24 or 48 hours contain comparatively little glycine but large amounts of serine compared with the control; this has been observed on several occasions. Results with hydroxyproline are not so definite, but twice it appears to have been metabolised with production of glutamine. Similar observations show that several other amino-acids are metabolised when infiltrated singly into plucked shoots, and the transformations which occur are in most cases similar to those reported in studies with mammalian tissues. Thus the amino-acid pattern in withered leaf is not due merely to a simple hydrolytic breakdown of protein. An extension of these studies is hoped to

throw some light on the mechanism of caffeine increase during withering.

Chemical Basis of Quality :

Work under this head was commenced in 1956 and is intended to continue as a major item of research for an indefinite period. Starting with a small number of clones, or *jats*, which are known to give teas of widely differing quality, the limited objective at present is to explain the 'Tasters' order of preference for individual liquor characters in terms of the chemical composition and biochemical behaviour of the green leaf and made tea. If this objective is achieved the investigation will be extended to include less pronounced differences in quality, for instance between teas made from similar *jats*, or from a single *jat* growing in different districts. At the same time, when opportunity affords, observations will be made on teas manufactured in different ways from a common source of leaf.

Research of this type is not new. Many previous attempts have been made, both at Tocklai and at other research centres, to explain quality in terms of chemical composition, but the results on the whole have been disappointing. No very precise information has resulted, but merely a number of generalisations to which there are many exceptions. The probable explanation of this is that the chemical measurements have not covered a sufficient range of ingredients and that, particularly in the case of the polyphenol complex, groups of chemicals rather than individuals have been measured. A notable example of this earlier work was that published by Harrison and Bose in 1942 (*Sankhya* 6, 151). For four *jats* representing a range of quality they found no correlation between valuation and any of the chemical constituents which were measured. The latter comprised total polyphenol, soluble solids, caffeine, phosphate and potash. These and similar results emphasise that the liquoring characteristics of a tea are not due to just one or two simple ingredients but to a combination of many different factors.

In recent years our knowledge of certain components of tea leaf, especially the polyphenols or "tea tannin", and of the changes they undergo during fermentation, has increased considerably and improved techniques have become available for their study. For this reason the time was considered appropriate for renewed attempts at determining the factors responsible for the various liquoring characters of teas.

In this first year of the new investigations the leaf from four areas at Borbhetta has been manufactured at intervals throughout the season, three times during the second flush (May-June), six times during the "rains" period (July-September) and three times during the autumnal season (end October-November), on each occasion portions of the fresh leaf, withered leaf and made tea being subjected to chemical analysis. Samples of the four teas have been reported on by our Tasting Panels in London and Calcutta as well as by the Tocklai Tea Taster. The four areas, each planted with seed of separate origin, were chosen for their known differences in quality. Fifteen separate components of the fresh leaf, four of the withered leaf and fourteen of the made tea were measured, as well as the activity of the oxidising enzyme in the fresh leaf. The techniques used for measuring oxidised catechin fractions in made tea were those developed by Dr. E. A. H. Roberts, the I.T.A. Research Officer in London. Unfortunately no figures are yet available for the individual catechins of fresh leaf. An attempt was made to measure these separately but the method used gave inconsistent results; fresh attempts are in hand. Statistical analysis of the mass of data obtained is far from complete, but as a matter of interest some of the figures are given in Table 2 below where it appears that they follow the same trend as one or other of the liquor characters.

The figures for soluble solids, total polyphenol and caffeine of the fresh leaf are percentages on a dry weight basis. The QO_2 is a measure of the rate of consumption of oxygen during fermentation and is determined by the activity of the oxidising enzyme. Fractions 1 and 2 of made tea are the ethyl acetate extractable and non-extractable portions respectively of a

Table 2

Area		36	34	21	2A
Tasters' Assessments	Infused Leaf ...	36	40	61	45
	Colour ...	36	42	54	59
	Strength ...	33	42	56	59
	Quality ...	27	42	57	49
	Briskness ...	30	42	59	50
	Valuation (Rs.)	2/10/4	2/14/-	3/3/5	3/1/4
Fresh Leaf	Soluble Solids ...	48.59	49.16	50.52	49.87
	Total Polyphenol	29.12	31.12	32.48	32.01
	Caffeine ...	3.35	3.90	4.03	4.01
	Qo ₂ ...	17.6	17.3	18.3	19.2
Made Tea	Fraction 1 ...	.512	.514	.602	.592
	Fraction 2 ...	1.39	1.41	1.59	1.74
	Theaflavins ...	.136	.165	.207	.189
	Thearubigins ...	1.284	1.251	1.330	1.572
	Volatile Matter ..	137.8	145.9	150.6	151.1

standard infusion; theaflavins and thearubigins are discussed in the report of the I.T.A. Research Officer, London. The figures for all four are the light absorption measured at 440 millimicrons in a 1 cm. cell. The results for volatile matter are in arbitrary figures.

It will be seen that the figures for Infused leaf, Quality, Briskness and Valuation follow a trend in which the order of preference is 21, 2A, 34, 36. Colour and Strength follow a slightly different trend in which 2A is preferred to 21, with 34 and 36 third and fourth as before. The chemical ingredients which have been included in Table 2 all follow one or other of these trends, and the Qo₂ follows a trend which is rather similar to that for Colour and Strength. So far it has been shown that in the fresh leaf caffeine and water soluble solids are correlated with Strength, Quality and Briskness, while total polyphenol is not correlated with any liquor character; in the made tea fraction 1 and theaflavins are correlated with Strength, Quality and Briskness while fraction 2 is correlated with Strength alone. From earlier studies it is believed that Strength is due to a combination of polyphenols and enzyme activity.

and the figures in Table 2 for total polyphenol and Q_{O_2} suggest that the product of the two will follow closely the trend for strength; the correlation has not yet been calculated.

No finality is implied by the results of this year's experiment, and it will be necessary to examine many more sources of leaf before final conclusions can be drawn. It is perhaps rather remarkable that in the present instance so many properties of the leaf should follow so nearly the same trend, and it is unlikely that this would be the case if another four leaf sources were chosen at random. The correlation between caffeine and liquor characters is somewhat unexpected when compared with the results of Harrison and Bose quoted above, who found that the *jat* with the highest valuation had the lowest content of caffeine.

The Volatile Constituents of Tea :

This work was continued by Dr. N. B. Chanda during his period of study in the U.K. The mixed hydrazones from the volatile matter of a Darjeeling tea were separated on a column of alumina. One pure fraction and several partially separated fractions were obtained. The ultra-violet absorption spectra of all fractions were plotted and the absorption maximum of the pure fraction determined. Carbon and hydrogen analyses were done on the pure fraction, its melting point measured, and from X-ray powder photographs the spacing of the lines was calculated. It is hoped that the data obtained, together with its infra-red absorption spectrum which is to be measured by the Chemistry Department of Edinburgh University, will establish the identity of the compound.

MANUFACTURING EXPERIMENTS

Trials with Tobacco Cutter :

A specially modified Little Giant roller, with circular open-top jacket, flat table and interchangeable E. P. fittings similar to those illustrated in the Annual Report of the Tea Research Institute of Ceylon for 1947, was installed towards the end of the manufacturing season. This roller is intended principally to work in conjunction with the tobacco cutter, and various

trials are planned for 1957. The one trial that was possible in 1956 suggested that neither of the two continuous rollers which are under development in the Engineering Branch are very suitable for rolling tobacco-cut leaf.

Continuous Roller Trials :

Numerous trials were conducted in conjunction with the Engineering Branch to compare the two continuous rollers with conventional manufacture and with C.T.C. manufacture. Results are reported under the Engineering Branch. In previous years our C.T.C. machine has been used at rather a wide setting. This year the rollers were set as close as possible, and the C.T.C. teas produced in these trials were very favourably commented on by the Calcutta Tasting Panel who on occasions considered them equal to the best Assam C.T.C. teas of current manufacture.

Manufacture of Clonal Leaf :

During the period July to September leaf from the three Tocklai released clones, 20/23/1, 19/29/13 and 1/7/1, and from the F_1 progeny of the "Gaurisankar" mating scheme, was manufactured several times in comparison with that from a light-leaf *jat* widely grown in Upper Assam. Both conventional and C.T.C. manufacture were given and the teas sorted into standard grades. Tasters' reports emphasised the superiority of all four sources, even the teas made from "Gaurisankar", which is of Manipuri origin, receiving on average distinctly higher valuations than the *jat*. On one occasion the tea from clone 1/7/1 received valuations from three different Tasters which averaged $14\frac{1}{2}$ annas per pound more than the valuation of the *jat*, manufacture being by C.T.C. In 1957 some of these clones will figure in the experiment designated "Chemical Basis of Quality."

PUBLICATIONS

The following scientific papers were published in 1956:

- Roberts, E. A. H., Cartwright, R. A., and Wood, D. J.
The leucoanthocyanins of unprocessed tea-
leaf. *J. Sci. Fd. Agric.* 7, 253.

Roberts, E. A. H., Cartwright, R. A., and Wood, D. J.
The Flavonols of Tea. *J. Sci. Fd. Agric.*, 7,
637.

ADVISORY

Advisory Correspondence.—Letters of an advisory nature issued during the year numbered 118.

Touring.—The Senior Blochemist visited 15 gardens, either to give advice on manufacture or to carry out experiments.

BIOCHEMICAL BRANCH—TEA TASTING SECTION**J. M. TRINICK—Tea Taster****STAFF**

Mr. J. M. Trinick, Tea Taster proceeded on U.K. leave on the 16th May and returned on the 19th October. Mr. R. C. J. H. Gilchrist acted for Mr. Trinick from the 16th May to 29th September. Mr. A. K. Barooah remained with the Section from April to September as an unpaid tasting student. Mr. R. K. Dutta was appointed stenographer on the 1st March.

TASTING

Approximately 6,000 samples were tasted during the season. These consisted of Tocklai's experimental manufacture, clones and also factory experimental teas and clones from commercial estates.

ADVISORY

Touring.— The Taster visited the following estates in connection with manufacture.

Heeleakah, Dessai Parbuttia T.E.'s.

Meetings.— The Taster attended the 12th and 13th Annual Conferences.

Lectures.— Four lectures on tea manufacture were given by the Taster to students of the Assam Agricultural College.

Courses.— The Taster gave three lectures on Tea Manufacture involving rolling, fermentation, green leaf sifting, firing and sorting at the three lecture courses held in March. The Taster also lectured on faults in clonal manufacture and gave a demonstration at the two clonal courses held during October.

Advisory Correspondence.— Approximately 250 letters of an advisory nature were issued during the year. The majority of these consisted of manufacturing advice after tasting samples.

ENGINEERING DEVELOPMENT BRANCH

I. McTEAR—Senior Research Engineer

D. N. BORBORA—Assistant Engineer

STAFF

Mr. I. McTear, Senior Research Engineer left on Overseas leave from the 15th October. Mr. D. N. Borbora was transferred temporarily to the Engineering Development Branch and has been Acting as Research Engineer from 10th September, 1956.

RESEARCH AND EXPERIMENT

Withering :

A full scale commercial leaf trolley was fabricated to provide a visual example for visitors to assess the various aspects of Tocklai form of Controlled Wither. The trolley comprises 66 trays and is capable of holding 660 lbs. of green leaf spread at 3.50 lbs. per square yard. The largest size of Two-stage controlled withering tunnel is designed to accommodate 18 trolleys of this size. Output of such a tunnel will be 75 maunds of fresh leaf withered to the desired degree every 1.5 to 2 hours depending on the wither after an initial starting up period of similar duration. The trays of the trolley are so designed that they can be made to stay in a horizontal position when they are drawn out for spreading, discharging withered leaf is a simple matter of dropping down the tray about the pivot at the end of its horizontal travel.

The trolley has been fabricated for use under observation at Cinnamara Factory in order to assess the behaviour of the various parts in use in Commercial Factories.

Continuous Withering Machine :

A Prototype Continuous Withering Machine was fabricated in 1956. The machine consists of a sheet metal tube inside which a metal scroll or helix rotates. This helix is mounted on a central sheet metal tubular duct on which perforations are made at suitable intervals to allow heated air to be blown

through the leaf held between the helix and the outer tube. Fresh leaf is fed at one end of the tube and is gradually pushed out to the other end by the slowly rotating helix. Air is forced through the central tube by means of a fan, on the intake side of which an Electric Heater unit is installed. Several trials with this machine were made towards the end of the year and withers ranging from 8.1 to 12% per hour were obtained. Comparative manufacturing trials to assess the effect of this form of withering on quality were not undertaken last year—an aspect which will be studied in the 1957 season.

Continuous Rollers :

Modifications to improve the performance of the two continuous rollers were carried out throughout the year. Continuous Roller No. 1 is a screw-fed rotary action roller of tubular construction while the Roller No. 2 is of trough formation and of reciprocating action. These prototype machines were operated in competition with conventional three crank rollers and C.T.C. machines. The teas were tasted and compared by three panel of tasters at Tocklai, Calcutta and London.

Teas processed by the continuous Roller No. 1 were somewhat unorthodox in appearance and after a careful study of the tasters opinions, it was decided to operate the Roller No. 1 in co-operation with C.T.C. machine and as both these machines are continuous in action they constitute a natural combination.

The Roller No. 2 very closely interprets the action of conventional rollers and as such development and modifications were directed towards producing conventional teas by this continuous machine. A study of the behaviour of leaf on conventional three crank rollers show that adequate processing of the teas in such machines demands freedom of the leaf to roll against each other, avoidance of interlocking of leaves during rolling and turbulence in the leaf bed, so that the entire charge of leaf undergoes the desired degree of processing action. This should again be gentle and not too severe otherwise the appearance of the teas will be adversely affected.

Measures were taken to simulate these conditions in the Roller No. 2 and the objective have been largely achieved by

alterations to the various components of the machine and some modifications to the machine proper to allow a desired degree of freedom to the leaf in its passage through the machine to open out and roll again to promote an even degree of processing action in all portions of the leaf bed.

The average valuations obtained in competitive tests were as follows :—

	Calcutta.	London.	Tocklai.
(a) Normal 3 roll mfg.	Rs. 3/2/5.4	Sh 6/6. 9d	Rs. 2/15/6.4
(a) Roller No 2 ('R' Type).	Rs 3/2/10.4	Sh 6/3.15d	Rs. 2/14/9.8
(b) Normal Roll + C. T. C.	Rs. 4/7/2.5	Sh 7/6 d	Rs. 4/ 0/5
(b) Roller No 2 + C. T. C.	Rs. 4/7/9.5	Sh. 7/4.1d	Rs. 3/15/1.5

While it is not always easy to reconcile various Brokers' opinions on teas of similar samples the overall picture presented would seem to indicate that machine development has reached a stage where the difference in the product produced by orthodox machines of the batch-processing type and the continuously operating machines, in prototype form, do not show much divergence. One Broker commenting upon a batch of tea samples representing four different methods of manufacture, using similar leaf and wither percentage, processed by Roller No. 1 (The Tubular and rotary action machine) plus C.T.C. wrote as follows :—

“We consider that the teas of Set “D” (Roller No. 1 + C.T.C.) would realise prices on the present market (dated 5th October, 1956) comparable with the finest Assam C.T.C. teas being offered.”

It may be pointed out that the teas produced by Roller No 2 ('R' Type) in competition with normal 3 × 30 minute rolls were the product of a machine repeatedly subjected to change. In consequence it is not to be expected that such teas can compete on equal terms with a process which has been practised and studied over many decades. Towards the end of the season the action of this machine had been improved considerably so that the information gained is available for the commencement of forthcoming manufacturing season.

Mechanical Harvesting Machine :

Trials with this machine described in Annual Report 1955, was continued throughout the season with minor mechanical improvements. The test area at Borbhetta in which this machine is tried out was tipped with the help of this machine and this was done twice to obtain a suitable plucking table. The plucking level was raised continually as the season advanced and counts of different fractions of the harvested crop were made.

A certain amount of reliance was placed on fitments directed towards elimination of coarse leaf and immature shoots. The results were encouraging in as far as elimination of coarse leaf was concerned and the coarse fraction harvested by the machine was gradually reduced from the high figure of 18% to as low as 6%. However it was noticed that this greater selectivity tended to promote a "banji" condition on the bushes towards the closing stages of the season. It seems that more frequent plucking rounds than the customary 7 day round may be equally selective without selectivity fitments.

There seems little doubt that different periods of the growing season require dissimilar methods *i.e.* rapid growth may accept fitments on the machine designed to discard coarse leaf and immature shoots whilst periods when growth is slowed down (as is the case towards the latter stages of the season) would respond better to what is commonly referred to as "plucking black" : In other words the machine should be operated in such a manner that combines the process of cleaning-out with normal harvesting. This will inevitably entail elimination of unmanufacturable leaf, to be considered as a separate subject.

Information regarding these aspects will be studied during the forthcoming season as well as the development of a machine, now in the experimental stage, designed to eliminate coarse unmanufacturable leaf.

Mechanical Pruning Machine :

Development of the pruning machine was continued in 1956. The machine was slightly modified to suit the require-

ments for pruning tea and mounted on the mechanical harvesting machine for pruning trials. In pruning tea, the desired conditions are that :—

- (a) The cutter must leave behind a clean cut on the pruned branches, level or parallel to the lie of the land.
- (b) The machine action should not disturb the branches beyond the minimum required for the purpose so that bruising or splitting of the branches is avoided.

These aspects of the problem were attended to, and a new arm of suitable sweep was fitted on the vertical spindle which was driven from the I. C. Engine by a 'V' belt drive at one third the engine speed. At the two ends of the revolving arm are fitted twin-bevelled circular cutting discs. A shield is provided below the arm to protect the bushes from the rotating parts of the machine as the machine moves forward over the pruned surface. Only a small portion of the cutting disc projects beyond the front end of the shield. A few short prongs are attached to the forward end of the shield to minimise the disturbance of the branches and to provide a degree of branch fixation during the forward motion of the machine.

With these fitments on, it is possible to light prune mature tea bushes at the rate of 20 bushes per minute without an appreciable amount of splitting of the cut ends. Trials were also made with different shapes and length of cuttings edges. It was found that the abrupt cutting action of shorter cutting edges promote splitting and that longer cuttings edges tend to reduce splitting.

PUBLICATIONS

Articles on different aspects of development of Tea Machinery were written by Mr. I. McTear, Senior Research Engineer under the headings :—

- 1. Mechanical Harvesting of Tea.
- 2. Controlled Withering.
- 3. Continuous Rolling Machines.

These were published in "Two and a Bud" Vol. III, No. 3.

ADVISORY.

Drawings and explanatory notes regarding Tocklai Withering Tunnel were supplied to 13 members and Agency Houses during the year. Members visiting the Station from time to time evinced keen interest in the Withering Tunnel and Continuous Rollers.

GENERAL

A demonstration of the tea machines under development at Tocklai was arranged for the 13th Session of the Annual Conference held in November, 1956.

The mechanical harvester-cum-pruning machine was demonstrated before the specially appointed Panel of Planters on 23rd/25th July, 1956. The Panel's views have been expressed in the report submitted by them.

Construction of two staff quarters to accommodate the two chargemen of this branch was taken up towards the end of the year.

ASSAM ADVISORY BRANCH—ASSAM VALLEY

P. M. GLOVER—Senior Advisory Officer, Assam.

P. C. SHARMA—Assistant Advisory Officer.

STAFF

The Senior Advisory Officer was on local leave 10th-16th December inclusive. Dr. P. C. Sharma completed his training and proceeded to Cachar on 26th April, 1956 to act for the Advisory Officer, Cachar during the latter's absence on U.K. leave.

Messrs. W. J. Grice and D. J. Gray joined the Advisory Branch at Tocklai on 20th September, 1956 and began their training in the Agricultural Branch. Mr. Mitra continued his training in the various branches throughout the year.

TOURING

The following garden visits were made by the Senior Advisor Officer:-

Assam Valley (South Bank):

<i>Jorhat Circle</i>	10 gardens.	<i>Nowgong Circle</i>	1 garden.
<i>Golaghat Circle</i>	8 gardens.	<i>Nazira Circle</i>	10 gardens.
<i>Moran Circle</i>	7 gardens.	<i>Doom Dooma Circle</i>	21 gardens.
<i>Panitola Circle</i>	14 gardens.	<i>Dibrugarh Circle</i>	4 gardens.
<i>Sonari Circle</i>	5 gardens.	<i>Nahorkatiya Circle</i>	7 gardens.

North Bank:

<i>Tezpur Circle</i>	3 gardens.	<i>Bishnauth Circle</i>	8 gardens.
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Several visits were of more than one day's duration. A number of gardens were visited on several occasions. Included in the above are visits to 3 estates, non members of the Indian Tea Association.

Cachar :

Two visits were made to Cachar and to Cachar Branch Head Quarters and 12 gardens were visited accompanied by the Advisory Officer on the first visit, and by the Acting Advisory Officer Cachar on the second.

Ranchi District :

The Senior Advisory Officer paid a special visit of one week's duration of the Assam Frontier Company's gardens in Chota Nagpur, Ranchi District, Bihar.

MEETINGS

The Senior Advisory Officer attended the following meetings during the year :—

Annual General Meeting Surma Valley Branch Indian Tea Association—8th February.

Planters Panel Mechanical Plucking—23-25th July.

Meeting with Messrs. Massey Harris Ferguson Representatives—5th August.

Annual General Meeting Assam Branch Indian Tea Association—17th November.

LECTURES AND DEMONSTRATIONS

The Senior Advisory Officer, Assam gave the following lectures :—

"Shade"	Panitola Club	...	20th January.
"Shade"	} Bishnath Club	...	27th June.
"Seed Bari Maintenance"			
Discussions	Behali Club	...	28th June.
"Shade"	Doom Dooma Club	...	21st July.
"Shade"	Retreat Club, Cachar	...	16th August.
"Shade"	Nahorkatiya Club	...	14th September.

Each Lecture was followed by questions and discussions embracing a wide range of subjects.

An address on "Practical aspects of spacing and arrangement of tea plants in Commercial Tea Estates" was given on Wednesday 14th November at the Thirteenth Annual Conference.

The following demonstrations were attended :—

Trench digging with the Barford Trench digging Implement at Negheriting T. E.—18th October.

Uprooting by Ferguson Tractor and Winch at Sycotta T.E. on 1st December.

Subsoiling with a Ferguson and a Fordson Tractor at Cinnamara T.E. on 28th December.

Spraying demonstrations using the Four Oaks Tractor mounted sprayer were given at Cinnamara on 24th April and at Balijan North on 23rd May.

COURSES

The Senior Advisory Officer gave a Lecture on "Some practical Aspects of Selection and Vegetative Propagation under Commercial Conditions" on each of the courses on Vegetative Propagation run by the Agricultural Branch in October, 1956.

Three Lecture Courses each of four days' duration were held in March, and were conducted by the Advisory Branch, with the assistance of the Tea Taster. A talk on the principles governing controlled wither was given by the Senior Biochemist, and a demonstration of the Tocklai Withering Tunnel was given by the Resident Engineer. A total of 81 attended of whom 8 were Planters from non-member gardens, and 7 were trainees from Borbhetta.

On each course the mornings were devoted to lectures and the afternoons to outdoor demonstrations.

ADVISORY CORRESPONDENCE

672 letters and memoranda of an advisory nature were written during the year, of which 31 were to non-member gardens.

PUBLICATIONS

The following Tea Encyclopaedia Serials were published during the year :

"Shade" T.E. Serial 46/1 revised in co-operation with the Senior Agriculturist.

"Silviculture of Shade" T.E. Serial 111 New Serial with the Senior Agriculturist and the Senior Advisory Officer, West Bengal.

“Pruning of Young Tea (Assam kinds)” Serial 10/2,
revised in co-operation with Senior Agriculturist.

“Care and Maintenance of Seed Baries” Serial 22/1
revised in cooperation with Senior Botanist.

“Control of Primary Root Diseases of Tea” Serial 70/1
revised in cooperation with the Mycologist.

The following articles were published in “Two and a Bud” :—

“Manuring with Special Reference to the Use of Mixtures
containing Nitrogen Phosphate and Potash”,
Vol. 111 No. 1 March, 1956.

“Toxicity of Pesticides” in conjunction with the Senior
Entomologist, Vol. 111 No. 4, December, 1956.

TECHNICAL REPORTS

Brown and Grey Blight (*Colletotrichum camelliae* and *Pestalozzia theae*) :

A notable feature of the year has been the prevalence of Brown and Grey Blight following upon sunscorch as a result of the abnormally hot dry spell early in July. The incidence was greatest on poorly shaded sections and in those plucked to a low measure.

In severe cases raising the plucking table by one leaf and application of additional nitrogen at 20-40 lbs. per acre in September proved beneficial.

Drainage :

The dry spell referred to in the previous paragraph was followed by a very wet period in late July early August, and the ill effects of too high a water table were observed on many gardens whose drainage was inadequate.

Red Spider (*Oligonychus bioculatus*) :

This pest has been particularly severe this year ; among districts more than usually affected were Dibrugarh and Panitola.

Pink Mite (*Acaphylla steinwedeni*) :

Pink mite has been severe on a number of gardens.

Looper (*Biston suppressaria*)

Looper attack was particularly severe in the Bishnath Circle, and while touring the area some interesting observations were made.

The attack was in general worst along road and drain sides, and on weak bushes on the sandy patches so characteristic of many North Bank gardens. An unusual feature was that Koroï (*Albizzia procera*) was the shade tree most severely attacked, and that a circle of tea bushes beneath this shade tree was often virtually stripped of leaf. Bacterial wilt halted the infestation late June early July.

Endrin at $\frac{1}{2}$ pint in 60-100 gallons was found to be much more effective than D.D.T. though due to danger of toxic residues on the made tea when using this insecticide special precautions are necessary unless the bushes are to be left unplucked for at least one plucking round following spraying.

The Barford Trench Digging Implement :

This machine costing Rs. 8,500/- is used in conjunction with a Fordson Major Tractor, and will cut a trench 22"-24" deep, 11" wide at the top and 5" wide at the bottom at the rate of 6' per minute or better.

It is considered that this machine suitably modified would be of considerable value on gardens whose soil is heavy, and who hedge-plant using trenches instead of pits. This method has many advantages in any event on heavy clay soils.

Four Oaks Tractor mounted sprayer :

This mechanised sprayer was found to be most satisfactory on some gardens ; on others the pump proved very troublesome. This and other faults have been taken up with Messrs. Four Oaks and it is hoped that in the models now arriving these faults will have been rectified.

EXPERIMENTS

Multi level NPK Experiments :

Three levels of nitrogen N_0 , N_{40} and N_{80} , with three levels of P and K, 0, 40 and 80. At N_{80} an additional level 20 lbs. per acre of both P and K is added. There are 34 treatments, in two repeats.

(a) **Panitola T.E.—Mature Tea.**— In the second year of the experiment again only nitrogen has produced a significant increase in yield ($P=0.001$). 80 lbs. nitrogen was significantly better than 40 lbs. Neither P nor K had any effect and the NK, NP, PK and NPK interactions were not significant. At 80 lbs. N there are four levels of P and K, and here also no significant effect was produced by either, nor were the interactions significant.

(b) **Panitola T.E.—Young Tea.**— Young tea 4' x 4' square two years old from planting. In the second year of the experiment the effect of treatments was based on weight of prunings and also of leaf. In both cases only potash produced a significant effect ($P=0.001$). Again as in 1955 both K_{40} and K_{80} produced a significantly greater total weight of prunings than plots receiving no potash. The difference between K_{40} and K_{80} was not significant at the 5% level. At 80 lbs. N there are four levels each of P and K. Again only potash produced a significant effect ($P=0.001$). The effect of treatments was based on weight of prunings and of leaf. In so far as prunings are concerned K at 20, 40 and 80 lbs. is significant over check; but there is no significant difference between levels. In so far as leaf was concerned all levels of K gave yields significant over no K, but in this case the yield from K_{80} was significantly better than from K_{20} and K_{40} .

(c) **Sockieting T.E.—Young Tea.**— This experiment was terminated on the sale of the garden early this year.

(d) **Borjuli T.E.—Mature Tea.**— This experiment is of a different design, there being only two levels of nitrogen 40 and 80. At each level of nitrogen there are three levels of P and K,

these being 0, 20 and 40. Check plots are $N_0P_0K_0$. There are 19 treatments, in three repeats.

In the first year of application of fertilisers there was no significant difference between individual treatments. The overall effect of fertiliser was however significant over no manure.

(e) Murmuria T.E.—Young Tea.— In this experiment there are three levels of nitrogen 80, 120 and 160 and at each level of nitrogen three levels of P and K 0, 20 and 40. A total of 27 treatments in three repeats. Preliminary yields were taken in 1956, and fertilisers will be applied for the first time in 1957.

(f) Margherita T.E.—Young Tea.— The treatments in this experiment are identical with those at Murmuria T.E. Preliminary yields will be taken in 1957.

Manuring on Bheel Soils :

At Sephinjuribheel T.E. in Cachar conducted by the Scientific Officer, Jokai Assam Co. In 1956 as in previous years all treatments involving phosphate and potash gave yields significantly greater than from check plots or plots receiving nitrogen alone at 40 lbs. N per acre ($P=0.05$).

80 lbs. phosphate and 120 lbs. potash gave the highest yield, and this was significant over all treatments except 40 lbs. phosphate and 80 lbs. potash. At 80 lbs. phosphate and 120 lbs. potash the addition of 40 lbs. N significantly decreased yield.

The differences between other treatments $N_0P_1K_1$, $N_1P_1K_1$, $N_0P_1K_2$, $N_1P_2K_2$, $N_1P_2K_4$ were not significant.

Inorganic versus Organic Nitrogen :

(a) At Halem T.E.— This experiment is now in its 25th year. Treatments are No manure, Cattle manure at 16, 000 lbs. per acre, and 40 lbs. Nitrogen as Sulphate of Ammonia with additions of 20 lbs. each phosphate and potash. As in 1954 and 1955 the yields from both organic and inorganic fertiliser were significantly greater than from the check plots ($P=0.001$).

The difference in yield between organic and inorganic fertiliser was not significant at the 5% level.

(b) **At Jamirah T.E.**— This experiment is now in its 9th year. Treatments are No manure, 80 lbs. of Nitrogen as oil-cake, and 80 lbs. Nitrogen as Sulphate of Ammonia. As in 1954 and 1955 both inorganic and organic fertilisers gave yields significant over the unmanured plots ($P=0.001$). On this light soil the difference between yield from organic and inorganic fertiliser was not significant at the 5% level.

Shade Nitrogen and Plucking :

An experiment on the interaction of Shade, Nitrogen and Plucking at Hunwal T.E. is now in its ninth year. Treatments are Shade and No shade. Two levels of tipping 6" and 9" and two levels of nitrogen 40 lbs. and 80 lbs., each with 40 lbs. phosphate and 40 lbs. potash. In 1956, the overall gain from the higher level of nitrogen was 4.34 maunds ($P=0.001$). Shade gave an increase of 1.94 maunds ($P=0.01$). The new young shade planted in 1953-54 is now beginning to become effective. Tipping level had no significant effect at either level of nitrogen or whether shaded or unshaded.

Disease of Tea Flowers attributed to Sclerotinaceae :

A field trial was laid out in the Dangri 1950 planted Seed Bari in conjunction with the Mycologist using Fernide (T.M.T.D.) as a 0.25% solution ($2\frac{1}{2}$ lbs. in 100 gallons) with the addition of 2 ozs. Teepol 710 per 100 gallons. Four applications were made during the flowering period in October-December 1955. Application was made with a Universal Major Sprayer towed behind a Fordson Tractor driven in 2nd gear at about 3 miles per hour; 180 gallons of spray fluid were utilised per acre per round.

The net gain in saleable seed per acre was 1.48 maunds (difference required for significance at the 1% level 0.89 maunds). Treatment had no detrimental effect on seed size or on the percentage of sinkers as assessed by counting the number of seed in one pound daily and putting them through a sinker/floater test.

While it appears that the treatment has been beneficial in increasing seed yield, it would be unwise to base any concrete conclusions on the results of a single field trial. It is intended to repeat treatments in October-December, 1957 using a suitably modified layout in which spraying with water alone will be included as a treatment, in view of the fact that a correlation exists between final seed crop obtained and rainfall at the period of flowering.

ASSAM ADVISORY BRANCH—CACHAR

E. D. HEATH—Advisory Officer

STAFF

During 1956, the Advisory Officer proceeded on U. K. leave, leaving the Branch on May 30th and returning on December 21st. In his absence, Dr. P. C. Sharma, Additional Advisory Officer, was in charge.

Mr. P. Chowdhury joined on 1st May as second Field Assistant and Mr. B. K. N. Majumdar on 21st May as Meteorological Assistant.

TOURING

108 visits were paid to gardens, including six non-member gardens, in the Chatla Bheel, Hailakandi, Chargola Valley, Longai Valley, Happy Valley, Lakhipur and North Cachar Circles.

MEETINGS

Mr. Heath attended the Annual General Meeting of the Surma Valley Branch Indian Tea Association, and Dr. Sharma the Tocklai Annual Conference, November 11th-16th.

LECTURES AND DEMONSTRATIONS

Longai Club :

May 15th.

“Red Spider and its Control” by Mr. Heath. “Common Stem and Leaf Diseases of Tea and their Control” by Dr. Sharma.

Retreat Club, Silchar :

August, 16th.

“Shade” by Mr. Glover, and “Silviculture of Shade” by Dr. Sharma.

Informal discussions were held in most clubs when the Advisory Officer was on tour.

COURSES

Mr. Heath attended the Annual Lecture Courses, March 9th to March 28th at Tocklai.

PUBLICATIONS

Four issues of the "Cachar Quarterly" were published during the year. The demand for this publication from non-member gardens continues to be quite good.

Cachar Advisory Branch Memorandum No. 1 "Drought and Tea", was published in April.

EXPERIMENTS

BRANCH EXPERIMENTAL AREA

Experiment to determine the effect of terminal bud removal from young tea plants in a 1 year nursery :

Dangri seed was planted out in December 1955 in the Branch nursery. The treatment carried out was the removal of the terminal bud and first leaf during a banjhi period in May, *i.e.* when the plants were 5-6 months old, and 6-8 inches high. The object was to promote the formation of side dahl* and branching in preference to upright growth, without any loss in vigour. The experiment was replicated on two other nurseries on commercial tea estates in Cachar.

In order to determine simply any treatment differences, collar diameter measurements were taken with a Rabens gauge in January, 1957 from treated and untreated seedlings; it being considered that collar diameters are a comparable indication of vigour and growth.

In the branch experiment, with 50 treated and 50 untreated plants, the treated plants showed an average of 20% larger collar diameter at 1 year of age than the untreated. A 't' test on the populations showed this to be significantly in favour of the treatment at the level of $P=0.001$.

*"dahl" = branch or shoot

The experiment will be repeated at Borbhetta during 1957 prior to making any general recommendations.

Nitrogen in Single and Double Doses :

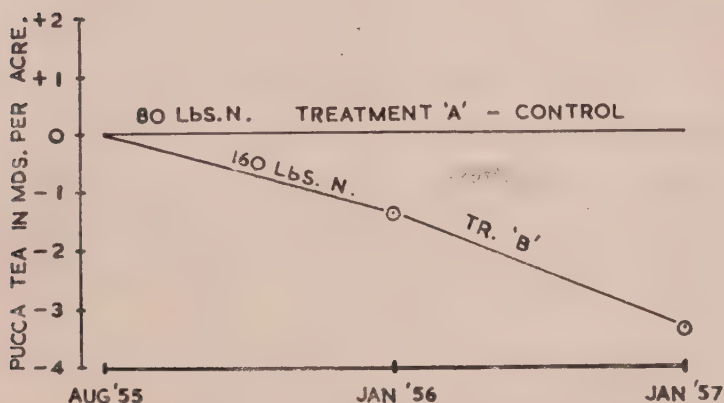
A small field trial (ABBA pattern) was laid out on dark-leaved jat under heavy *Albizzia chinensis* (= *stipulata*) shade in 1955. The tea is on a teela crown, planted in 1947 at $4\frac{1}{2}'$ triangular. Plot size is 100 bushes.

Treatments were :

- A. 80 lb. N. (Sulphate of Ammonia) applied in March.
- B. 80 lb. N. (Sulphate of Ammonia) applied in March and 80 lb. N. applied in July, total 160 lb. Nitrogen.

Leaf records were commenced on 12-8-55, and have been taken every plucking round since. The effect of the treatments over the past two seasons is best illustrated by the graph below (Figure 1.)

FIGURE - I.



After the first application of manures in 1955, the end of season total crop was reduced by 1.4 maunds/acre made tea as a result of the extra 80 lb. nitrogen applied in July. By the end of 1956, total crop for the year was further reduced by 3.35 maunds/acre made tea by the extra 80 lb. nitrogen in July.

Actual figures for each replicate each year are given in table 1.

Table 1 : Yield of Green Leaf in lbs/plots

Year	Treat. A.		Treat. B.		Sig. Diff.
1955	143	157	114	151	...
1956	277	268	218	239	52.2 (P=0.05)
Mean	211		180		

It is concluded that for this tea under such heavy shade, high nitrogenous manuring (160 lb. nitrogen) even in two doses, is detrimental to yield.

In the next two years, treatments will be amended as follows, to obtain further information.

Treatment A (1957 onwards) 80 lb. N in March.

Treatment B (, ,) 80 lb. N in March.

40 lb. N in August.

GARDEN EXPERIMENTS

Pruning/Skiffing Experiments :

These experiments were started in 1955 on five commercial gardens in the district. As each one carries a treatment involving a 3-year pruning cycle, it is not proposed to publish any results until one complete cycle has been completed, viz. 1957.

N. P. K. Experiments :

BHUBANDHAR N.P.K. EXPERIMENT

Started in 1955 in a section of tea planted on bheel soil in 1919 at 5' × 5' triangular. Shade was replanted in 1955 at 45' triangular. Plot size is 105 bushes and there are three replications of 7 treatments, making a total of 21 plots in 3 blocks of 7 plots each. The experimental layout is in randomized blocks.

Treatments are :

- | | |
|----------------|----------------|
| 1. $N_0P_0K_0$ | 5. $N_0P_1K_2$ |
| 2. $N_1P_0K_0$ | 6. $N_0P_2K_2$ |
| 3. $N_0P_0K_1$ | 7. $N_1P_2K_2$ |
| 4. $N_0P_1K_1$ | |

0 denotes no manure, 1 denotes 40 lb., and 2 denotes 80 lb. N_2 , P_2O_5 , or K_2O per acre.

Manures were applied first in May, 1955, and again in May, 1956. Tabulated yields are given in tables 2 and 3 below.

Table 2 : 1955 Yield in lbs. fresh leaf/plot
(adjusted to 100 bushes)

Block.	Treatment							Total
	1	2	3	4	5	6	7	
I	119	147	96	103	125	162	116	868
II	121	114	133	165	84	97	127	841
III	118	180	157	139	149	102	101	916
Total ...	358	441	386	407	358	361	344	2655
Mean	119	147	129	136.	119	120	115	

Sig. Diff. ($P=0.05$)=156

Table 3 : 1956 Yield in lbs. fresh leaf/plot
(adjusted to 100 bushes)

Block.	Treatment							Total
	1	2	3	4	5	6	7	
I	111	125	96	127	106	105	122	792
II	120	115	150	138	97	136	117	873
III	110	111	135	115	142	122	110	845
Total :	341	351	381	380	345	363	349	2510
Mean	114	114	127	127	115	121	116	

Sig. Diff. ($P=0.05$)=87

This experiment to date has shown no significant result, possibly because of the high-vacancy count which has appeared in various plots, apparently irrespective of manurial treatment. The experiment will be continued a further year to see if any trends develop.

Pathini NPK Experiment.— Treatments here are the same as in the Bhubandhar experiment above. The tea is Manipuri, planted 4' 6" triangular, under mixed even shade. Plot size is $2 \times 40 = 80$ bushes per plot. All plots are separated by a 1 row guard line (discard). The experiment commenced in 1956. The area is on a bheel soil. Tabulated results of the 1956 plucking season are given in table 4 below.

Table 4 : 1956 Yields in lbs. Green Leaf/Plot

Block	Treatment							Total
	1	2	3	4	5	6	7	
I	187	174	196	205	185	162	209	1318
II	180	231	185	251	133	183	162	1328
III	205	226	223	203	212	241	200	1510
Total :	572	634	604	659	530	586	571	4156
Mean	191	211	201	220	177	195	190	

Sig. Diff. ($P = .05$) = 148

It is worth noting the similarity in yields from the treatments at Pathini and at Bhubandhar, particularly with regard to nitrogen alone and a mixture of phosphate/potash alone.

District Clonal Trial :

In conjunction with the Agricultural and Physical Chemistry branches of Tocklai, a clonal trial has been initiated at Silcoorie Tea Estate. Clones used are 20.23.1; 19.29.13; 28.2; 107.4 and 16.12.15, all being good rooters have been selected to represent the main types of tea. Five nitrogen

treatments will be applied, viz., 0, 40, 80, 120, and 160 lb. N. per acre. There are three replications of each treatment, and the number of plants per plot is $3 \times 8 = 24$.

The layout is a split plot design covering 1.31 acres approximately. Planting distance is $5' \times 2'$.

The entire experiment is replicated twice, once in a clay flat, and once on a teela. The experiments will run concurrently with identical experiments in other districts. The basic purpose of this experiment is to establish regional differences by observing the reactions of the standard clones to different environments.

Branch Vegetative Propagation Work :

Of the six clones initially selected here, and propagated on four occasions during 1955 and 1956, one has proved itself to have exceptional vigour. Although rooting percentage was initially low due to inexperienced labour, this has now been stepped up to over 90% success.

Although the clone is planted in the nursery at 8" apart, it has made such vigorous growth that the average spread of the plants is 14". Side branches from low down on the stem have crossed each other in their efforts to spread. Providing that transplanting proves easy there should be a future for a clone with this vigour. It has proved fairly resistant to drought and to Red Spider. During 1957, yield and tasting trials will be conducted.

Red Rust Control Trials :

Red Rust trials were carried out in Silcoorie Tea Estate in 1955/56.

(a) Dhurumkhal 1949 Extension

Treatment.—Removal by pruning of all infected branches in May, 1955 and subsequent spraying of Perenox.

Effect.—Estimated on 24.4.56. Visual observation indicated that in the area generally, Red Rust fructifications had just reached maturity, and sporing had started. The treated

area showed less degree of infection than the untreated, but as infection previously was so severe, bushes were much reduced by the heavy pruning necessitated, and at least a further year will be necessary to determine whether this compensates for the reduction in Red Rust. Neighbouring tea, untreated other than with Perenox, appeared to be equally as badly infected as last year, and it was expected that much new wood would die back again, thus further reducing the spread of the tea.

(b) *Doorgakhona 1951 Extension :*

Treatment.—Defoliation in May, 1955 of all leaves below the pruning level, followed by Perenox spraying.

Effect.—Estimated on 24.4.56. Visual observation indicated that the incidence of Red Rust in the treated area was very considerably reduced compared to the surrounding untreated areas. Only one or two bushes treated showed slight signs of Red Rust fructifications, and this was high up on the frames. The majority of bushes appeared to be entirely free of Red Rust. In the adjoining tea, Red Rust was very prevalent. Spring here was more advanced than at Dhurumkhal, and virtually every bush carried the infection in a bad or very bad degree; this was in spite of 3 rounds Perenox spraying last year. Side branches were "red from top to bottom." Shade trees were likewise severely infected, and the incidence appeared generally worse than at the corresponding time last year.

The defoliation may have very slightly reduced the vigour of the tea, but this was barely noticeable. Leaf recording is proposed in this area to determine more precisely the effect of the treatment. First appearances however are highly satisfactory.

Further observations will be taken during the 1957 spring season.

SILCOORIE STATION REPORT

Visitors :

S. K. Dutta, Esqr., Senior Agriculturist, visited the branch from January 10th-21st and accompanied the Advisory Officer to 9 gardens.

P. M. Glover, Esqr., Senior Advisory Officer, Assam, visited the branch from February 2nd-9th, and accompanied the Advisory Officer to 5 gardens, and again in August when he accompanied Additional Advisory Officer on visits to 10 gardens.

H. Ferguson, Esqr., Director of Tocklai, visited the branch from February 7th-9th, and accompanied the Senior Advisory Officer, Assam and Advisory Officer, Cachar on a garden visit. The Director and Senior Advisory Officer accompanied the Advisory Officer to the Surma Valley Branch, Indian Tea Association Annual General Meeting.

Mr. K. C. Sharma, Mycologist, visited the station in April to investigate the early appearance of Black Rot and Red Rust.

Dr. G. M. Das, Senior Entomologist, Tocklai, accompanied the Additional Advisory Officer to two gardens in July.

Dr. G. M. Das, accompanied the Additional Advisory Officer on an extensive visit to Silcoorie Tea Estate in December to study the Flushworm outbreak, and two Entomological Assistants were temporarily attached to the Station to study the life cycle and habits of Flushworm (*Enarmonia leucostoma*.)

WEST BENGAL ADVISORY BRANCH

R. I. MACALPINE—Senior Advisory Officer.

STAFF

The Advisory Services in West Bengal were reorganised at the beginning of 1956. Mr. Swan, at that time Advisory Officer in Darjeeling and Terai was transferred to Tocklai as Scientific Officer, Headquarters, and for the time being the Dooars, Darjeeling and Terai were combined for advisory purposes into a single unit. This report therefore refers to all areas of West Bengal. The Senior Advisory Officer Mr. R. I. Macalpine was on overseas leave from 12th March—14th October and during his absence advisory visits were made from Tocklai by the Senior Agriculturist and the Scientific Officer, Headquarters.

TOURING

During the year 72 Tea Estates were visited. Of these 69 were member Gardens and 3 non-member Gardens. Of the total number of visits made, the Senior Advisory Officer was responsible for 21, the Senior Agriculturist 36, and the Scientific Officer, Headquarters 15.

MEETINGS

The Senior Advisory Officer attended the 12th Annual Conference at Tocklai on 20th—22nd February and the 13th Annual Conference from 12th—15th November.

COURSES

Due to absence on leave the Senior Advisory Officer was unable to participate in the Annual Lecture Courses.

ADVISORY CORRESPONDENCE

Over 340 letters of an advisory nature were issued during the year.

EXPERIMENTS

The following experiments, initiated in the year shown against each, were continued.

DOOARS EXPERIMENTS

N. P. K. Manuring :

Kalchini T. E. (1954).— In one section three levels of nitrogen (0, 40 and 80 lbs. N/acre) and then nine combinations of P & K at 0, 40 and 80 lbs. P_2O_5 and K_2O per acre, randomly imposed to each whole plot are being compared. In a second block sixteen combinations of 4 levels of each P and K with 80 lbs. N per acre are being compared.

Nitrogen Manuring under shade :

Baradighi Tea Estate (1956).— This experiment is to test effect of nitrogen at 0, 40, 80 and 120 lbs. N/acre on yields of tea under *Albizzia odoratissima* shade. During the year initial yields were recorded.

Times of Pruning :

Central Dooars Tea Estate (1955) and Chuapara Tea Estate (1956).— The effects on total crop and crop distribution by pruning at monthly intervals from 15th November to 15th February are being tested.

Pruning Cycles :

Baradighi Tea Estate (1955) and Chuapara Tea Estate (1956).— The effect on total yield and crop distribution under annual and biennial pruning is being tested. In the triennially pruned plots, in the “unpruned” year the effect of three degrees of skiffing, viz. light, medium and deep are also being compared. Provision has been made in one series of plots to offset seasonal variations in climatic conditions by medium skiffing in the year the biennial plots are pruned.

Seed Garden (Stock 203) at Nagrakata :

Planting out of this seed garden commenced during the year. By the end of the year 4 units were completed, 8 units partly completed. Variation in the size of plants from clone to clone has necessitated retention of some till the spring.

District Clonal Trials :

During the year growing stock for establishment of this trial at Nagrakata Tea Estate was received from Tocklai and is being held in nurseries at Nagrakata Headquarters. A similar trial with other clones included is also being established at Chuapara Tea Estate. While these trials involve primarily the comparison of clones, their basic purpose is to establish climatic and soil differences between different regions by indicating the interactions to different environments of the standard clones which are being used in all these experiments.

Miscellaneous Observations at Nagrakata :

Seed of the following tree species were sown in nurseries for experiments in alternative shade tree species.

Albizzia richardiana

Acacia lenticularis

Acrocarpus fraxinifolius

Albizzia amara

Celtis tetrandra

Celtis australis

Albizzia julibrissin

Casuarina equisetifolia

The last two have failed completely, and others have shown varying growth in the nursery.

DARJEELING EXPERIMENTS**N. P. K. Manuring :**

(a) **Margaret's Hope Tea Estate (1940).**— This experiment was continued. In this experiment which was devised to test effect of Nitrogen alone, N in combination with Phosphate and Potash and P and K alone, the levels of each of P and K were raised in 1952 from 60 lbs. per acre to 120 lbs. per acre of P_2O_5 and K_2O . Nitrogen where it is applied is being retained at 60 lbs. N per acre.

(b) **Rungneet Tea Estate (1954).**— This experiment replicates in high elevation tea that established in Kalchini Tea Estate described above, and is similar to it in design.

Pruning Cycles :

Nagri T. E. (1951), and Mim T. E. (1951).— These test the effect on yields of biennial, triennial and quadrennial pruning cycles. Provision is made to compare the effects of skiffing as against unpruned in the triennial cycle plots, and also skiffing in the 2nd year of the cycle as against skiffing in the 3rd year of the cycle.

Times of Pruning :

Puttabong (1953).— This tests the effect on yields in high elevation tea of times of pruning. Pruning is done at monthly intervals.

Individual Bush Selection :

Miniature manufacture of leaf from 23 selected bushes was carried out during the year.

INDIAN TEA ASSOCIATION (LONDON) CHEMICAL LABORATORY, BUTLER'S WHARF

E. A. H. ROBERTS—Senior Biochemist.

INTRODUCTION

This is the first time that the Annual Report of the Tocklai Experimental Station has included an account of the fundamental work on the Chemistry of Made Tea now being carried out in the laboratory at Butler's Wharf. This account will not therefore be restricted to the results of the last twelve months but will also embrace some of the work carried out in previous years.

It was also thought desirable that some of the more purely chemical work should be placed on record. Such work is included in the appendix at the end of this report.

RESEARCH

Thearubigins and theaflavins :

A considerable proportion of the colour of a five minute infusion has been shown to be due to the presence in tea of a group of brown pigments, which will be referred to in future as the **THEARUBIGINS**. These thearubigins are acids, and account for at least 10% of the dry weight of a black tea. In addition to these thearubigins the tea contains at least eight other substances which are new to chemical science. Two of these, **THEAFLAVIN** and **THEAFLAVIN GALLATE** (known collectively as the theaflavins), are bright yellow in colour and make quite a substantial contribution to the colour of an infusion. Two other pigments, referred to by the code letters **P** and **Q**, make only a slight contribution to the colour, and the other four new substances, **A**, **B**, **C** and **Z**, are colourless.

Quantitatively, the thearubigins and theaflavins are the most important substances in a black tea, and they account for almost all of its colour and strength. As a result of fundamental investigation into their chemical behaviour, analytical methods have been developed for the estimation of thearubigins

and theaflavins in tea infusions. So far it has not been possible to express the results in terms of percentages in the teas by weight, and the figures obtained are in arbitrary units.

From analyses already carried out on commercial teas from North East India and elsewhere it is apparent that there is a correlation between tasting reports and the values obtained for theaflavins. High thearubigin contents are also desirable, but the theaflavin content is the more important factor. A high level of theaflavins is associated with the desirable golden colour of an infusion, whereas teas with a low theaflavin content are described as grey, plain or dull.

These analytical methods have also been applied to a study of the effects of variation in time and temperature of fermentation. Typical results are quoted in the table below:

Table I : The effects of varying time and temperature of fermentation on the production of theaflavins and thearubigins

Fermentation conditions		Colour intensities in infusion		
Temperature	Time (hr.)	Theaflavins	Thearubigins soluble in ethyl acetate	Thearubigins insoluble in ethyl acetate
80°F	1	0.53	0.17	1.09
	2	0.70	0.40	1.85
	3	0.56	0.43	2.11
	4	0.56	0.38	2.09
	5	0.42	0.32	2.26
70°F	2	0.60	0.41	1.52
	3	0.63	0.46	1.89
	4	0.52	0.41	1.97
90°F	2	0.48	0.46	1.80
	3	0.40	0.38	1.92
	4	0.30	0.35	1.98

From the above results it will be seen that the theaflavins reach a maximum level comparatively early in the course of fermentation. In the later stages of fermentation the thearubigins

are increasing at the expense of the theaflavins, and it appears probable that thearubigins are actually produced as a result of further oxidation of the theaflavins. Further evidence in favour of this view will be found in the appendix.

This explains the adverse effects of over-fermentation where increased depth of colour has been achieved at the expense of theaflavins, as in the tea fermented for 5 hours at 80°F. It will also be observed that theaflavins reach a higher level at 70°F than at 90°F (these experiments were carried out with comparable samples of leaf), and that the rate of destruction of the theaflavins in the later stages of fermentation is faster at the higher temperature. The known adverse effects of high temperature fermentation are thus satisfactorily accounted for, as it is established that the theaflavin contents are lower in the teas fermented at the higher temperature.

From such results as these it has been concluded that the theaflavins and thearubigins are the substances in a black tea which are largely responsible for the liquoring properties.

The acidic character of thearubigins may prove to be of some practical significance. In tea there is an excess of acids over bases, so that any particular acid will be present partly as the free acid and partly as salts, mainly those of potassium. It has been established that both the free acid and the salts of the thearubigins are present in an infusion. The salts of the thearubigins are appreciably darker in colour than the free acids, and will almost certainly differ in taste. The ratio of bases (potassium, calcium etc.,) to thearubigins and other organic acids should therefore be an important factor in determining liquoring characters. In the comparatively limited number of teas examined so far this ratio has not varied very much, but this possibility will receive further consideration.

The origin of theaflavins and thearubigins :

It can be deduced from the colour of withered leaf that the theaflavins and thearubigins are not produced during withering, and other experiments have shown that none of the other substances formed during manufacture are produced at this stage. It has been established that all of these substances

are produced during fermentation as a result of the enzymic oxidation of what used to be known as the tea tannin of green leaf. This so-called tea-tannin has been shown to be a mixture of more than twenty phenolic substances, but only two of these, epigallocatechin and epigallocatechin gallate, undergo extensive chemical change during fermentation. Problems associated with the origin and nature of the fermentation products in manufactured tea therefore become reduced to a consideration of the oxidation products of two parent substances only. This is a very considerable simplification of what appeared at first a very complex problem, and it has already led to some progress being made in elucidating the chemical nature of the theaflavins and thearubigins, and also of some of the other products of tea fermentation.

APPENDIX

The chemical composition of green leaf :

Many of the substances detected in black tea occur also in green leaf. As green leaf is a much simpler chemical system than black tea the identifications of these substances have been carried out with green leaf extracts.

Four main classes of polyphenols have been found in green leaf, including flavanols (formerly known as the catechins), depsides, flavonol glycosides and leucoanthocyanins. The flavanols account for the greater part of the total polyphenols and have already been sufficiently described. The only important new development is that a previous prediction that d-gallocatechin would be found in green leaf, and not the dl-mixture, has been confirmed. The depsides found in tea include chlorogenic acid, neochlorogenic acid and three new substances theogallin and two isomers of p-coumarylquinic acid. Theogallin, which has been shown to be a gallic acid ester of quinic acid, is one of the more abundantly occurring polyphenols in tea. Flavonol glycosides found in tea include kaempferol-3-glucoside (astragalin), kaempferol-3-rhamnogluside, kaempferol-3-rhamnoglucoside, quercetin-3-rhamnoside (quercitrin), quercetin-3-glucoside (isoquercitrin), quercetin-3-rhamnoglucoside (rutin), quercetin-3-rhamnoglucoside,

myricetin-3-rhamnoside (myricitrin), myricetin-3-glucoside and myricetin-3-rhamnoglucoside. The two last named substances have not previously been described. Tea-leaf also contains leucoanthocyanins, both leucodelphinidins and leucocyanidins having been detected.

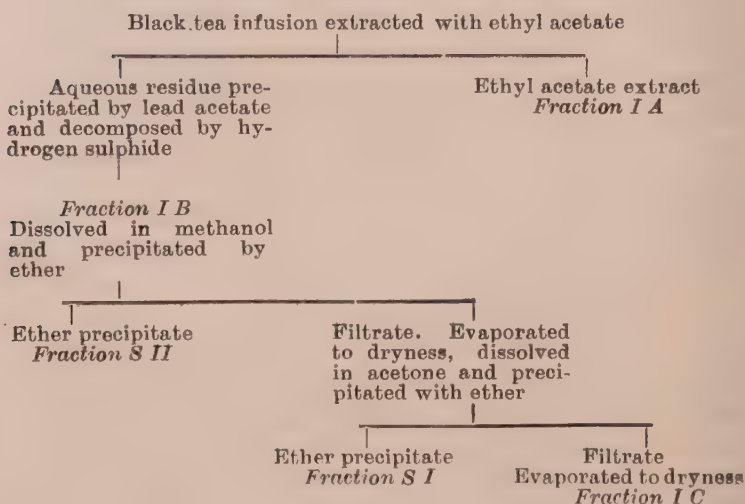
It has been necessary to obtain most of these substances in pure form in order to study their behaviour on enzymic oxidation during fermentation.

The only non-phenolic substance in green leaf to have received detailed consideration has been the amino-acid theanine. The chemical structure suggested for this substance by Japanese workers has been confirmed.

The fractionation of black tea extracts :

Black tea represents a very much more complicated mixture of substances than the green leaf, and it was found necessary to break it up into several fractions before attempting to study its chemical composition by paper chromatography. One of several successful methods of fractionation is outlined diagrammatically below:

Table 2



A very considerable proportion of the brown pigments of the tea, amounting to about 10% by weight of the original tea, formed fractions S I and S II. These fractions consisted essentially of thearubigins, with only traces of other polyphenolic matter.

The ethyl acetate extract (I A) contained some thearubigins, which could be removed by shaking with sodium bicarbonate, and theaflavin and theaflavin gallate as the main pigments. The fraction also contained traces of pigments P and Q, gallic acid, the uncharacterised substances A, B and Z and many unchanged substances also found in green leaf. These included caffeine, flavanols, flavonol monoglycosides and traces of the depsides other than theogallin.

Fraction I C contained relatively small amounts of thearubigins, gallic acid, theogallin and the other depsides, the di- and tri-glycosides of the flavonols and substance C, which latter resembled A and B in its chemical properties.

The mechanism of tea-fermentation :

It has been established that the oxidation of l-epigallocatechin gallate in the presence of tea oxidase results in the formation of theaflavin gallate and A as the main products, with smaller amounts of gallic acid and traces of P, Q and Z. The main product of the enzymic oxidation of l-epigallocatechin is substance C. Enzymic oxidation of a mixture of these two flavanols results in the formation of the same substances formed from the individual flavanols together with theaflavin and substance B.

Neither theaflavin nor theaflavin gallate is oxidized by the tea oxidase, but if d-catechin is also present, the theaflavins are oxidized and the products of this coupled oxidation are chromatographically the same as the thearubigins. No such coupled oxidation takes place if l-epigallocatechin is substituted for d-catechin. These experiments suggest that the thearubigins are oxidation products of the theaflavins and therefore also oxidation products of l-epigallocatechin and its gallate. All the products recognized in a black tea appear therefore to be derived from these two parent substances.

The same conclusion is reached by a consideration of the oxidation-reduction potentials of the tea polyphenols. It has been shown that the oxidation-reduction potentials of l-epigallocatechin, d-gallocatechin and l-epigallocatechin gallate are lower than those of all the other polyphenols in green leaf. In the oxidation of a mixture of substances, those with lowest oxidation-reduction potentials are oxidized first, so that in tea-fermentation one would expect to find oxidation confined to these three flavanols. There is very little d-gallocatechin in tea-leaf, so that to a first approximation only l-epigallocatechin and its gallate are oxidized.

The other flavanols, l-epicatechin, d-catechin and l-epicatechin gallate, have been shown not to undergo appreciable oxidation during fermentation, since black tea contains approximately the same amount of these substances as the green leaf. However they appear to have an important role in fermentation, in functioning as carriers for the oxidation of theaflavins to thearubigins. This has not been demonstrated in the case of l-epicatechin and l-epicatechin gallate, but as d-catechin appears to function in this way it is very probable that the other two will behave similarly.

